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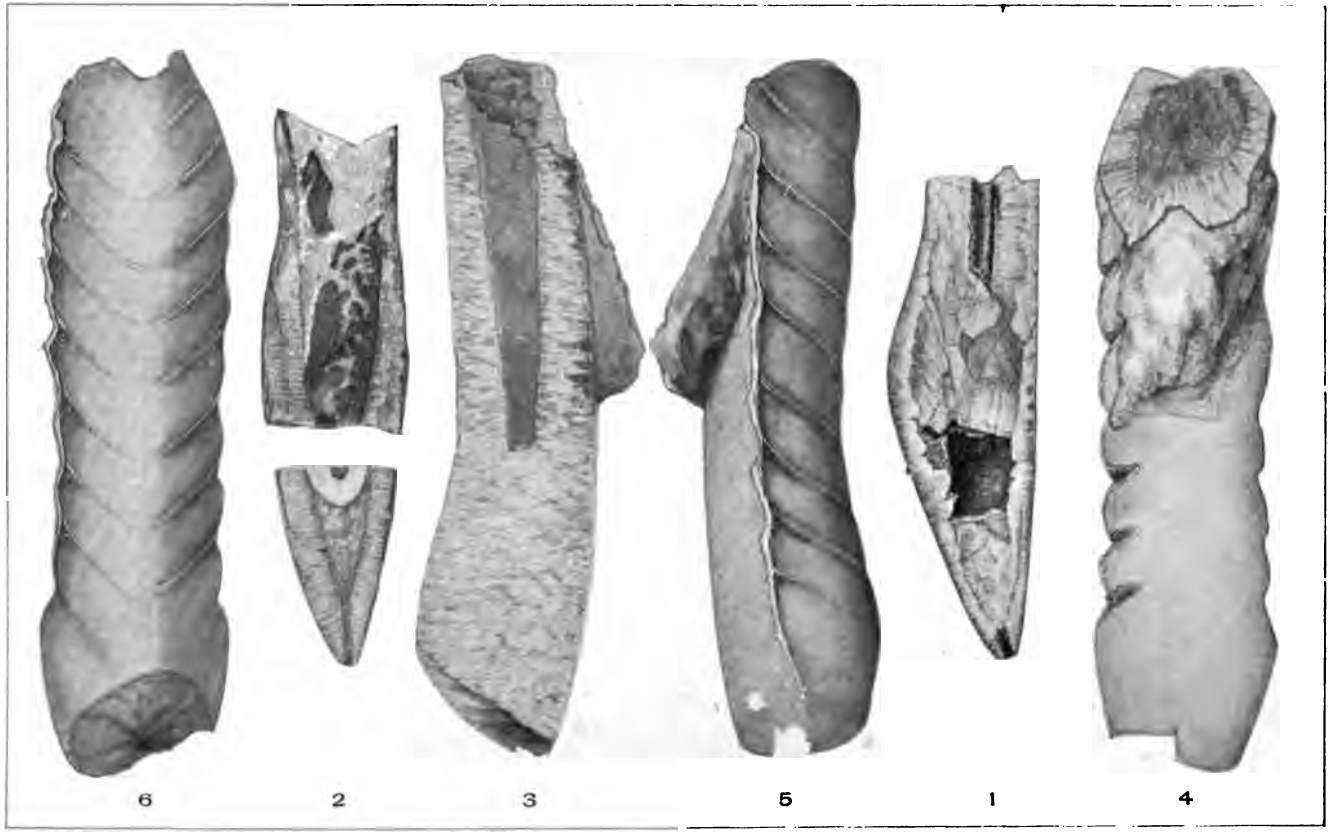
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NANNO AULEMA, CLARKE.

THE

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VOL. XVI. JULY, 1895. No. 1.

REMARKS ON THE GENUS NANNO, CLARKE.

By ALPHEUS HYATT, Boston, Mass.

(PLATE I.)

The discovery and description of this genus by Prof. J. M. Clarke has materially added to our knowledge of the structure and development of the siphon in the *Endoceratidæ* and thrown new light upon the affinities of the forms of this group. The endosiphon* is absent in the maturer stages of *Nanno* and probably also in *Vaginoceras*, and in *Sannionites* it appears to be present only in a fragmentary form in some species. Prof. Clarke's original specimens in some cases demonstrate the existence of an endosiphon in the young of *Nanno* and that it was in one stage an open tube. This gives a standard by which to judge of the affinities of the genera in the *Endoceratidæ* and shows clearly that *Endoceras* is the radical from which the genera *Sannionites*, *Nanno* and *Vaginoceras* were derived. Prof. Clarke having generously allowed me to study his types, I have made careful observations upon these interesting fossils. The specimens figured in his plate†, figures 5-7, are in my opinion the young of figure 1, as described by Clarke, and so are also figures 2 and 8. Figure 3 represents a full grown siphon of a specimen older obviously than figure 1.

*I have used the term siphon in this paper to facilitate comparison and reference to Clarke's paper. I usually use the term siphuncle for the calcareous tube and siphon for the fleshy tube.

†"*Nanno*, a new Cephalopodan type," J. M. Clarke, AM. GEOLOGIST, vol. XIV, p. 205, pl. 6, Oct., 1894.

I have been able to find the endocones of his figure 8, although there are only slight indications of their presence in this specimen, and the deposits are much more solid in this specimen than in any *Endoceras* I ever saw. They greatly resemble in color and general aspect those of *Narthecoceras*, mentioned below, and may have been built in the same way, namely, by the sheath while shrinking towards the central axis. This specimen is important because it shows clearly the alteration in shape of the sheath and that it has shrunk in size. There are no indications that it built any deposits while it was being withdrawn upwards except in a small patch on one side. Here the radiatory lines are inclined as if there had been a steady withdrawal upwards or orad at the same time that there was a shrinkage in bulk towards the central axis. The shape of this sheath explains the truncated end of that given in this paper, figure 1, and shows that the bevelled apical end of this and its acutely angular ventral point is really the normal form derived from this younger stage of the sheath. It shows also that this tube is not a true endosiphon, although it so closely resembles one, but is in reality the termination of a retreating sheath.

I have not been able to find satisfactory evidence of the general existence of *fibrous* radial structure. Obscure radiations occur but close study of these show that the radial lines are the apparent boundaries of pseudocrystals, not true fibres. They may be attributed to the mode of deposition of the calcareous matter, but can hardly be considered integral structures of the solid filling, which, in my opinion, is an amorphous pseudocrystalline deposit often denser than in *Endoceras* but only secondarily radiatory in structure. I do not wish to be understood as stating that the structure of the filling is not radiatory. On the contrary there is a decided radiation in the pseudocrystals that shows well on broken and abraded surfaces, but I differ somewhat from Prof. Clarke in my interpretation of the meaning of these lines. When radiating lines are present as integral structures the fibrous nature of the deposits are easily demonstrated. Such structures occur in the siphon of *Narthecoceras** a new genus of *Endoceratidæ*

*Since writing the above I have consulted one of my drawings and the fine specimen from which it was taken and find distinct but spo-

described in a paper I am now preparing for publication. The type is *Narthecoceras* (*End.*) *crassisiphonatum* (Whiteaves sp.)* The only known species are this and *Narth.* (*End.*) *simpsoni*, sp. Billings.

The youth of the specimens referred to above is in my opinion established by the aspect of the sheath. The sheath is complete in Clarke's figure 8 and approximately complete in the originals of figures 5, 7 and 2 and also 4. This is a most extraordinary fact considering the great variety of young specimens as a rule, and one might well claim that these were probably full grown. On the other hand the original of Clarke's figure 1, gives strong evidence in support of his conclusion that they are identical and belong to the same species. That they are each complete in their own stage is demonstrated by one of the specimens from Chatfield, figured here on plate I, figure 1. This is about the size and length of Clarke's figure 2 but is not a complete siphon like that specimen. It is a fragment of the apical end of some larger and older fossil. The sheath penetrating the center of the broken stem is represented by a narrow tube less than 2 mm. in diameter which at first seems to be an endosiphon.

Having examined the tips of the siphon in Clarke's specimens of *Nanno*, I found on each a broken place or scar indicating in one specimen, the original of Clarke's figure 2, possible contact with the external shell and having in the center what appeared to be the mark of an endosiphon. On each of the other specimens there were marks not wholly accounted for by abrasion, except in that of the original of figure 1, which is considerably worn. Suspecting that these indicated the presence of an endosiphon I ventured to make a section of the specimen described.

radic traces of fibrous deposition in a specimen of *Endoceras, E. proteiforme*? from the Trenton limestone. The filling varies from loose subcrystalline or sparry to comparatively dense, opaque, white with numerous lines of deposition, all of them parallel with the surfaces of the endocones. These are crossed here and there by curved lines which occasionally may have a fibrous aspect. Near the wall of the siphon there is, in one spot, a number of these lines that may be described as indicating a tendency towards fibrillization in the structure of the filling, and in other parts there are similar appearances especially near the wall of the siphon.

*The Orthoceratidæ of the Trenton limestone of the Winnipeg basin; Trans. Royal Soc. Canada, vol. IX, 1891.

H. W Wilson

The tubular sheath (fig. 1, pl. I.) extends apicad of the broken end to a length of 7 mm. without change of diameter, but bends slightly and is truncated or bevelled at the apical end forming an acute angle in the section on the ventral or straight side and an obtuse angle on the dorsal or gibbous side of the siphon. The whole length of the section is 31 mm., the greatest transverse diameter is 9.5 mm., and the diameter of the broken end is 7.5 mm. Apicad of this sheath the filling was not dense as in the original of figure 8 of Clarke, or figures 3-6 given in this paper, but very loose semicrystalline calcite, and in the middle of the broadest part the entire center was hollow with an intruded piece of the darker colored matrix on one (the dorsal) side. This local absence of deposits can be accounted for because the upper right hand side of the specimen removed in making the section, was crushed opposite this cavity. This wound may have been made during the life of the animal and, if so, this would account for the absence of deposits in the center as well as the loose subcrystalline aspect of the filling above. The character of the deposits and the differences between those of the periphery and central parts is given accurately in the figure. The dark mass on the left upper corner above the hollow space is the intrusive matrix alluded to above. This space was completely inclosed so that the matrix did not penetrate into its interior. The pseudocrystals surrounding it were distinctly visible through the hole in the wall of the siphon before the right side was cut away in making the section. The wound in the right side had been partly closed by these internal deposits as the animal grew in length but these repairs did not fill it out to the surface of the siphon, they merely shut off the entrance to the ventral parts of the hollow.

The peripheral deposits are radiatory in arrangement and evidently organic. These deposits are penetrated at the tip by the endosiphon which is a tube open at the end. The wall on the dorsal side is a distinct dark line showing that it was composed of conchiolin. The limits on the opposite side are less definite but perfectly perceptible. The center near the lower end is completely filled with the red matrix, identical in aspect with the piece of matrix on the left of the hollow above and that filling the interior of the truncated sheath.

The matrical filling of the endosiphon tails out internally, disappearing in the organic, calcareous, white deposits. The form of the filling proves clearly that the ananepionic endosiphon was open to the exterior like the sheath above and that it was closed during the life of the animal by internal deposits which did not completely fill the tube but left an irregular conical hollow at the tip which was plugged up by the ferruginous matrix after the death of the animal. The exact time of the internal organic closure was probably at the end of the paranepionic substage or beginning of the next or neanic stage. This young endosiphon in other words penetrated the first endocone and belonged to the same substage.

The earlier substage when the siphon was empty must have possessed a simple aperture connecting with the protoconch. To make this clearer to readers unfamiliar with recent investigations among cephalopods it is necessary to interpolate a short description of the stages of development among these forms.

The protoconch or earliest embryonic stage of the shell is supposed to have preceded the formation of the tip of the conch and to have communicated with the first living chamber in this tip through the endosiphon. This is naturally called the "prosiphon" by Zittell on account of its position, but the author considers it as not proven that this organ is in any sense a siphon. On the other hand it is when complete a differentiation of the tube formed by the tip of the sheath and it is at all stages distinct from the funnels of the surrounding siphon. The siphon is built up by the funnels which are formed by a differentiated zone at the base of the mantle, whereas the endosiphon is built by the probably thinner walls of a prolongation of the mantle called the fleshy sheath. There is always a sharp distinction between the internal deposits of the fleshy sheath and the funnels both in position and structure.

The ananepionic substage is a septaless living chamber with a cicatrix, oval or round in *Endoceratidæ*, the metanepionic has septa and a huge empty siphon, which in *Nanno* practically fill the interior of the apex, the paranepionic substage has a similar siphon but with the first endocone and an endosiphon formed in the apex and continuous with the open-

ing of the cicatrix. At the end of this substage or the beginning of the neanic (adolescent) stage the endosiphon was plugged up internally with calcareous matter in *Nanno*, as described above. The second endocone belongs to the first or ananeanic substage when the siphon begins to contract and there is no endosiphon.

Among the specimens there was another figured by Prof. Clarke only in part in his section, figure 4, to show the radial deposits. This proved so very peculiar and interesting that I have given an enlargement in plate I, figure 2, with the center omitted where Clarke's section was taken. The sheath in this is complete but has a rounded termination. The two endocones are present as in Clarke's figure 8 and the structure of the organic filling is the same but less dense than in that specimen and not so opaque. The interest centers in the peculiar density, rounded termination, and structureless aspect of the filling of the second endocone, immediately apicad of the tip of the sheath, and the contrast between this and the triangular space between this and the first endocone. In this triangular space the filling is looser and subcrystalline showing rapid deposition as if done by a retiring and comparatively rapidly moving fleshy sheath.

In completing the end of this section I opened up the endosiphon and, finding that the trace grew narrower nearer the center of the tip, ceased grinding. Subsequently upon close study by reflected light from a sheet of white paper I succeeded in seeing the dark trace of the endosiphon still below the surface but penetrating, as shown in figure 2, the entire thickness of the first endocone. Then by taking off a little more I found the endosiphonal walls below continuous as given in the figure, but the dark shade still allowed to remain in this figure has become less noticeable.

This observation shows that the endosiphon is not always precisely tubular and sometimes is not in the exact center so that it may be easily obliterated when rubbing down a specimen and may be present when not visible in a section taken through the center. That it was like that of figure 1, open to the exterior, is shown by the dark color of the matrical filling, which agrees with that of the sheath above, and it also belongs to the age of the first endocone as in that specimen.

Thus it seems clear that in *Nanno*, and possibly in *Sannionites*, in which genus the endosiphon is often absent in adults, this organ is clearly a characteristic of the metanepionic substage.

The opening through the apex of the empty, siphonless shell in the anepionic substage was not an endosiphon but a primitive organ or protendosiphon probably communicating with the protoconch.

The true endosiphon was formed by the tip of the swollen sheath while it was building the first endocone, which therefore belongs to the middle nepionic substage. Upon the entry of the animal into the paranepionic substage a rupture of the sheath and endosiphon took place and the sheath in closing at the apical end plugged up the endosiphon and began to build the loose filling immediately apicad of the tip of the second endocone. The second endocone was built as shown by Clarke's figure 8 and this figure 2, as the siphon was becoming contracted and it was completed after the siphon had assumed the proportions of the ephebic siphon so that this endocone should be reckoned as belonging to the ananeanic substage. These materials give the approximately exact history of these substages but they plainly show that the nepionic stage had an endosiphon which was lost at the termination of this stage and that at the beginning of the neanic stage there was still a large sheath with a more or less conical end, as in figure 2 and Clarke's figure 8, quite different from the elongated tubular termination of the same organ in the ephebic stage as shown in figures 1 and 3, yet agreeing with it sufficiently in figure 1 and Clarke's figure 8, to make it highly probable that the older sheath is only a shrunken modification of the ananeanic sheath.

This result does not in the least contradict Prof. Clarke's result that *Nanno* did not have an endosiphon, on the contrary it confirms this point and adds simply the fact, that this genus possessed an endosiphon only in the young and was probably therefore, a modified descendant of *Endoceras* which had this organ throughout life.

The original of Clarke's figure 3, having been cut by him, shows some extremely interesting and novel characteristics. The sheath is shown in plate I, figure 3, terminating abrupt-

ly and is somewhat different from figure 1, showing considerable variation in the form of the termination of the sheath. This is in part due to age, since this is obviously an older stage than that given in figure 1. It is probable that *Nanno aulema* was a short shell, all the indications being in favor of this opinion. If so the tubular termination of the sheath in figure 1, which is undoubtedly ephebic, indicates that the more abrupt and stouter termination in figure 3 is a degeneration due to age, and implies that the senile stage had been entered upon in this specimen before the animal died. There are no definite endocones and the filling is very solid and opaque, the radiation of the deposits is also less distinctly marked than at younger stages. The lower end of this fragment of a siphon is swollen slightly showing that the proximal part of the nepionic stage is present and that the distal, or younger part, only is missing. The shell is preserved and is shown in figure 4 on the ventral side and in figures 5-6. These figures demonstrate relations between the siphon and shell unparalleled in the history of similar fossils. The shell on the venter is in absolute contact with the walls of the siphon so that it becomes part of the siphonal wall on that side. Microscopal sections of more perfect specimens are needed to establish the details, but so far as can be determined by this fossil, it appears to be quite certain, that the septa and funnels, which exist on the dorsum of the siphon and which there and on the sides form the wall of the siphon, have entirely disappeared on the venter. This alone establishes *Nanno* as a new form of the *Endoceratidæ*.

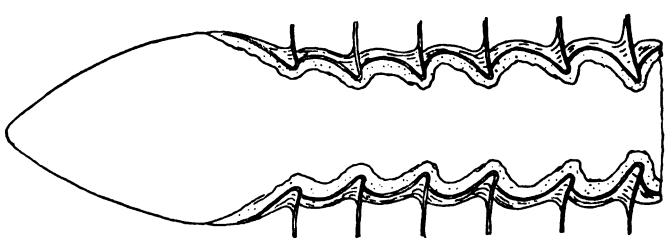


FIGURE 1.

The shell in the section, figure 3, is the outer or ventral wall of the siphon and in the ideal view, figure 1, page 8, the relations of the ventral shell to the siphon are shown as

they are supposed to be when the shell of figure 4 has been removed from around the edges. The funnels and remnants of the septa are shaded with vertical lines. These disappear when they come in contact with the shell and do not pass around the venter as in all other endoceratites. The substance or filling of the siphon is dotted and the remnants of the shell clinging to the venter and surrounding the apex of the siphon are not shaded.

The shell was thick and smooth, externally. The funnels on the dorsal and lateral aspects of the siphon were certainly present and appeared to form the wall of the siphon as they do in *Sannionites*, *Endoceras* and *Piloceras*, i. e., pass from one septum to the next, building a single wall. Nevertheless the length of the funnels was not actually traced except near the septa, and this conclusion, that they actually reach from one septum to another is an inference from the structure of allied forms of the same group. It is very common to find the isolated siphons of this family without the delicate shell of the lower parts of the funnels, but with remnants of the septa and upper parts of the funnels still attached to the solid siphon.

Vaginoceras (*Endoceras*) *belemnitiforme* Holm,* differs from *Sannionites* in having the siphon composed of longer funnels. Each septum in forming its funnel passes beyond and into the opening of the next funnel and reaches, in many cases, to a point opposite the opening of the second funnel apicad of its aperture. The wall of the siphon is, in other words, everywhere and in all stages later than the nepionic stage, double and composed of the apical and oval parts of two funnels. The young of *Vaginoceras belemnitiforme*, as figured by Holm, is very similar to that of *Nanno*, and filled the apex of the shell in the same way.

Materials for comparing the young of *Sannionites* and *Nanno* are wanting at present and, although the adults seem to approximate closely, it does not follow that the nepionic stages will be similar. There are two specimens in the collection of the Museum of Comparative Zoology, Cambridge, Mass., which appear to be the young of *Sannionites* (*Cameroceras*) *trentonnense*, sp. Conrad, and if so the young of this species

*Abhandl., Dames et Kayser, III, pl. 1.

has a much smaller neponic siphon than *Nanno*. The tips are decidedly similar in form, but have constrictions showing traces of the presence of funnels and septa to within a short distance of the apex. The siphon, in other words, is made up of funnels even in the nepionic stage.

Endoceras has siphons with swollen ends that in some species must have nearly filled the tip of the shell, but in other species this is not the case. There are similar phenomena in *Piloceratidæ;* some genera of this group have siphons as small as in *Sannionites* and compare with typical *Piloceras* as *Sannionites* compares with *Endoceras*.

The large size of the apical part of the siphon which approximately fills the the interior of the shell in *Nanno* caused that author to speak of this young shell in an article on "Cephalopod Beginnings"* as having a hugh protoconch. This view is also held by Holm and others in Europe, and is a natural inference from the general aspect of the swollen tip, but I held the opposite opinion in several papers before the publication of Ford's observations. These showed conclusively in *Piloceras* and *Actinoceras*, both of which have very large siphons in the young, that the apex of the shell had a deep cicatrix. This discovery shows clearly that the swollen tip of the siphon and shell is not a protoconch in the forms in which it occurs, but that the apex of the surrounding shell is a true conch, having a cicatrix like that of other nautiloids.

The view that this swollen apical part of the siphon is a protoconch is more likely to be taken in *Vaginoceras* and in *Nanno* than in *Sannionites*, *Endoceras* or *Piloceras*. In these genera the siphon may or may not have a swollen end and I am even doubtful whether the existence of this swollen, siphonal apex in the nepionic stage of the shell may not be a matter of individual variation in some species. I am quite sure, from the materials now on hand, and from Holm's figures of *Vaginoceras*, that it varies greatly in the same species. It is also a fact that when the siphon in this stage is swollen in *Endoceras* that it must have very nearly filled the interior of the beginning or earlier stages of the shell.

The septa are, however, traceable in some specimens notwithstanding the very narrow space in which they were de-

*American Geologist, vol. xv, p. 125, Feb., 1895.

veloped and it is obvious that the swollen end is sometimes made up of the funnels of from four to six septa and that the tip of the siphon is a coecal cone like that of other forms of nautiloids, differing principally in size.

In good specimens the extreme tips of these siphons bear marks of having been perforated by a hole that communicated with the apex of the shell layers, which seemed to have been plugged up as the siphon became filled with organic deposits. The evidence of this consists in the lighter or darker color of a central spot that appears on the apex of isolated siphons and is often much more decisive than the external marks on any specimen of *Nanno*. This spot is sometimes circular but may also be elliptical or irregular, and it differs usually in color from the outer surrounding surface and is continuous internally with the endosiphon.

The remarkable transitional form described by Clarke as *Orthoceras* with a protoconch makes the conclusion previously drawn from the existence of the cicatrix on the apices of *Nautilus*, *Orthoceras*, and *Piloceras*, much more reliable than it was previously. This discovery confirms the opinion that the division of the early stages into protoconch and conch is true probably of all nautiloids and the cicatrix upon the apex of the true conch is probably in all cases to be accepted as due to the removal of a protoconch.

This being true, the very close similarity of the younger stages of *Nanno*, *Sannionites*, *Vaginoceras* and *Endoceras* to *Piloceras*, makes it highly probable that the apex of the shell will be found to have an external cicatrix in the former, although it may not be such a deep pit as that already demonstrated in *Piloceras* by Ford and confirmed by my own observations upon the species in this country.

EXPLANATION OF PLATE I.

Nanno aulema Clarke.

FIG. 1. Fragment of the end of the siphon of a specimen in the ephebic stage, enlarged two diameters. This shows the endosiphon in the first endocone, filled by the red ferruginous matrix and closed internally by organic deposits, also the loose character of the remaining internal deposits, the hollow formed in the center by the absence of these deposits and a part of the narrow tubular end of the sheath above. Enlarged + 2 diameters. Locality, Chatfield, Minn.

FIG. 2. The entire siphon of a younger specimen in the ananeanic

substage, enlarged two diameters. It is somewhat younger than Clarke's fig. 8 and belongs to a larger specimen, but is nevertheless in the same substage of growth. In Clarke's figure the sheath is more shrunken in proportion and shows the approaching termination of the ananeanic substage. The triangular space between the first and second endocones is filled with the loose organic deposit of the paranepionic substage which plugged up the endosiphon of the metanepionic substage. The second endocone has a dense structure at the apex and belongs entirely to the ananeanic substage, as shown in this and Clarke's fig. 8. Enlarged + 2 diameters. Locality, Minneapolis.

FIGS. 3 to 6. Clarke's original of his fig. 3, enlarged about 2.3 to show details. This is a siphon belonging to a somewhat longer and older specimen than his fig. 1 when complete, and is perhaps at the beginning of the gerontic stage. Fig. 3 shows the shell on the venter forming the outer wall of the siphon and the abrupt termination of the sheath, which is larger and blunter in that of fig. 1 at a younger stage of growth.

FIG. 4 is the same specimen from the front, showing relations of shell to the septa and funnels on the left. Fig. 5-6 the same from side and back.

[CRUCIAL POINTS IN THE GEOLOGY OF THE LAKE SUPERIOR REGION. No. 5.]

STEPS OF PROGRESSIVE RESEARCH IN THE GEOLOGY OF THE LAKE SUPERIOR REGION PRIOR TO THE LATE WISCONSIN SURVEY.

By N. H. WINCHELL, Minneapolis, Minn.

Having now briefly noted the leading concurrent geologic events of the Taconic in North America as they are known to have occurred in regions surrounding the Lake Superior region, it is next in order to give more close attention to the Lake Superior region itself. The geological literature of this region may be separated into two parts, based on a historical datum, viz., the Wisconsin geological survey concluded in 1879 and fully published in 1883.

American geological opinion, while in the main making an onward advance in correct interpretation, has been oscillatory on more subjects than one. This has been owing in no small degree to the tendency of the human mind to overestimate its own achievements. When some new fact in science, or some new understanding of a group of facts, has been vividly portrayed and applied by some new investigator he has sometimes given such wide scope to the new truth that it has been

made the cause of serious error. It is not always under the lead of the discoverers that these new keys are misused, but their followers and imitators are prone to not only adopt the new ideas but to apply them to the solution of problems and to the fancied discovery of other ideas to which they have no relation. This tendency once started by an influential geologist is carried much farther by others, and still farther by their successors until the bad consequences become so evident that they are finally detected and their cause is discovered. Then commences a swing of the pendulum in the opposite direction, with perhaps equal exaggeration and equally serious errors. The later errors, however, are never duplicates of the old mistakes. They are on another plane, and their effects are less broad in scope though not less profound in originality and importance. By the amount of advance which separates the later plane from the arena, on which the earlier geologists operated, is the progress of the science measured, from generation to generation as the pendulum of opinion swings from extreme to extreme. Like a ship which makes headway by tacking into the wind, does geology constantly shift and constantly advance, though rarely or never straight ahead.

The Wisconsin geological survey served as one of the turning points in the progressive examination of the geology of the Lake Superior region. Almost everything before that, so far as relates to these formations, had been substantially in accord with itself—at least there were few dissentients from the leading classification which had been advanced in the middle and early in the latter half of the century. Before noticing the new ideas approved by the corps of the Wisconsin survey, it will be best to consider succinctly the ideas that were prevalent prior to that survey.

The officers of the Canadian geological survey were among the first to put forth generalizations upon the stratigraphy of the Lake Superior region. The tragic early death of Dr. Douglass Hughton, by drowning, cut short for many years the voice which American geologists south of the international boundary might have had in forming geological opinion on these rocks. He shared the views of Dr. E. Emmons, and many of the specimens collected by his field parties were labelled by him and referred to the Taconic system. Thus la-

belled they lay for many years in the museum of the University of Michigan.* His reports, however, were few and rather brief, and exerted but little influence. Meantime the views of the Canadian survey became current in American literature. The energies of the New York survey, and of the officials who inherited its results, were at this juncture expended in other directions. New York was the only state with an efficient geological organization that had a lively interest in the classification of these rocks. Those who are acquainted with the rather personal disputation which followed the official close of the New York survey will quickly apprehend the probable cause of the silence of the geologists of New York on this subject at a date when their voice would have been powerful. States further west entered later upon this field, and they were in a large measure forced to accept the principles and the general stratigraphy of the Canadian survey then in vogue. With slight exceptions they have not varied from the established nomenclature, nor from the early grouping of these ancient terranes as made out and published by the later Canadian survey.

The first important generalization by the Canadian survey was printed at Paris in the French language in 1855.† In this publication, after a brief description of the Laurentian, the Huronian system is defined in the following words:

Du système Cambrien ou Huronien.

Les bords des lacs Huron et Supérieur nous offrent une série de schistes, grès, calcaires et conglomérats, intercalés avec de puissantes assises de diorite, et reposant en stratification discordante sur le système laurentien. Comme ces roches sont inférieures au terrain silurien, et comme d'ailleurs elles n'ont jusqu' à présent offert aucun fossile, elles peuvent bien être rapportées au système cambrien (le cambrien inférieur de M. Sedgwick). Les schistes de ce système sur le lac Supérieur, sont de couleur bleuâtre, et renferment des couches de silex corné qui a des bandes calcaires, et dont les fentes sont souvent remplies d'anthracite.

Ces roches sont recouvertes d'une épaisseur considérable de trapp, sur lequel sont superposées de puissantes assises de grès blanc et rouge qui passent quelquefois à l'état de conglomérat renfermant des orbicules de quartz et de jaspe * * * *

*Compare also the lists published in Geol. Sur. of Mich. by Brooks, vol. II, p. 235, 1869-73; and "Jackson's report," giving rock samples collected in 1844, pp. 917-918 and 919.

†Esquisse géologique du Canada, LOGAN and HUNT. Paris, 1855.

Dans la formation correspondante de la rive septentrionale du lac Huron, on rencontre des grès ayant un aspect plus vitreux et des conglomérats plus abondants que sur le lac Supérieur, associés pourtant avec des schistes et des conglomérats schisteux semblables à ceux que nous venons de decrire, le tout offrant de grandes masses intercalées de diorite. Une couche de calcaire ayant une épaisseur de seize mètres forme une partie de cette série, à laquelle M. Logan donne une puissance de plus de trois mille mètres. M. Logan a constaté, après l'irruption des diorites interstratifiées, celle de deux systèmes de dykes de diorite, et une troisième de granite d'une époque intermédiaire entre ces deux derniers. La formation des veines métallifères appartient à une époque plus récente encore. Les espèces principales de ces veines sont le cuivre natif, le quartz, le spath calcaire, la dolomie, la fluorine et la barytine avec plusieurs zéolithes, dont la plus abondante est la laumontite: on y rencontre en outre la heulandite, la stilbite, la thomsonite, l'apophyllite et l'analcime, ainsi que la prehnite et le datholite. Ces veines ne sont métallifères que lorsqu'elles traversent les couches de trapp.

This statement, which doubtless was designed to embody the results of the Canadian survey to that date, covering the researches of Logan and Murray, on the Huronian of the region, is remarkable for three things:

1. The Huronian is made the equivalent of the Lower Cambrian of Sedgwick.

2. The Huronian includes the whole copper-bearing series of the region, including what is now styled Keweenawan. The little colored map which accompanies the work also demonstrates that.

3. The Huronian is said to be nonconformable on the Laurentian. It is probable that the locality about five miles east of the mouth of the Thessalon river, in the original Huronian region, was depended on for authority for this statement.

In 1863 Logan issued his great summary of Canadian geology,* in which he varies somewhat from the *Esquisse* of 1855. The assumed parallelism of the Huronian with the Lower Cambrian is not mentioned, and the copper-bearing rocks are divided into two series—the upper and the lower volcanic groups. These are said to lie non-conformably upon the Huronian, the upper group in the original Huronian region and the lower group in the Thunder Bay region. The two togeth-

*Geology of Canada: Report of progress from the commencement of the survey to 1863. Montreal, 1863, with an atlas.

er arc, with some hesitancy, made the equivalent of the Potsdam or of the Potsdam and Calciferous of New York state.

But a serious error was committed by Logan in this compilation, as has been pointed out distinctly by R. D. Irving. It consisted in not parallelizing the rocks of the original Huronian with the lower volcanic group (Animikie) of the copper-bearing series, in the vicinity of Thunder bay, and making them the equivalent of the lower slates at that point which are non-conformable below the lower volcanic group. This separation of the lower volcanic group in the region of Thunder bay from the Huronian necessitated the application of the term Huronian, by him and by all subsequent Canadian observers up to the time of A. C. Lawson, to the underlying schists, which has finally led to the extension of the term to all the schists and associated rocks downward to the Laurentian, and, further, to the assertion that the Huronian is conformable with the Laurentian, since these schists gradually merge into the gneisses which constitute the Laurentian in the Lake Superior region. Again, since these lower schists, with their associated greenstones, are by far the greater series and the most important of the schistose rocks of the region, they came soon to monopolize the term Huronian, and to determine its significance, thus greatly perverting its original sense and scope. It was this perversion that Irving and Lawson corrected.* The separation of these lower schistose and gneissic rocks from the term Huronian, and their designation under the new term *Ontarian* by Lawson, is a recent important classificatory step. However, these corrections have taken place since the Wisconsin survey.

With the exception of the non-identification of the Huronian with the copper-bearing rocks (both upper and lower groups), the later grouping by Logan agrees with his earlier. The effect, however, of his earlier publication remained with the British geologists, and remains to this day. They recognized and adopted Logan's term, Laurentian, but they make the Cambrian the equivalent of his Huronian.

Some years before Logan's classifications, as above, some United States geologists were surveying the copper and iron

*Compare N. H. WINCHELL, Methods of stratigraphy in studying the Huronian. AMERICAN GEOLOGIST, vol. IV, pp. 342-357, 1889.

lands in the Lake Superior region for the United States government. Their report appeared in 1851* and is accompanied by a map which, has a classification which, in the light of what is known now of the geology of the Lake Superior region, appears curious and fantastic. All the rocks are divided into aqueous, metamorphic and igneous formations, which, for a grouping as to origins, is not bad. The aqueous rocks extend down to and include the Potsdam sandstone and its underlying conglomerate the base of the "Silurian." Below that is the Azoic system, a metamorphic group, comprised in two parts, viz., "crystalline schists" and "quartz." The igneous rocks are represented as of two sorts, granite and trappean, the latter being sometimes associated with the Azoic and sometimes with the Silurian. As with Logan, the names and the classification of the New York series were employed as far as possible, the copper-bearing formation being at the base of the Silurian.

Examining this map more carefully, it is learned that under "Azoic" is included, essentially, the rocks of the real Huronian, viz., the area of the original Huronian and their extension on the east shore of lake Superior and the slates of the Thunder Bay district. The granitic and trappean rocks associated with these make up the Azoic. In general the Marquette and Menominee iron districts, and the area northwestward on the Brulé river as far as Lac Vieux Desert are fragmental Azoic. These are surrounded by igneous granite and pierced by trappean rock. It will be seen that Logan in 1863 followed Foster and Whitney in distinguishing the upper copper-bearing series as of Silurian age, but not in putting the slates of the Animikie in the Azoic. The copper-bearing series is placed bodily, as the equivalent of the Potsdam of New York. It seems further that Foster and Whitney were not aware of the existence of two series of slates in the Thunder Bay district.

After the foregoing the next contribution to the geology of the Lake Superior region which needs to be mentioned here was the report of the Michigan survey, conducted by Brooks, Pumpelly and Rominger. Major Brooks adopted the expand-

*Report on the Geology of the Lake Superior Land district. J. W. Foster and J. D. Whitney. Part II. 1851. Washington.

ed Huronian ideas of the Canadian survey, and attempted a delineation of the stratigraphic succession of the rocks of that system as exemplified in the Marquette district, making nineteen stratigraphic parts, to which he subsequently added one more, an eruptive granite supposed to be younger than all the others. He says nothing of the duplicate nature of the copper-bearing series, brought out by Logan in 1863, but only describes Logan's "upper volcanic group." He instituted, however, an important distinction in this series, as it had before been described, viz., he separated the traps and their tilted sandstones from the horizontal sandstones which he called Silurian. He does not seem, however, to be very positive about the validity of this distinction, since at his typical locality for examining the relations of these rocks* he calls attention to sandstones "*apparently* Silurian," which had a dip amounting to 45° toward the south. He says:

> So far as my observation has extended, this rule is general: that is, no Lake Superior sandstone which is unmistakably Lower Silurian has ever been found in any position other than horizontal: and no rock which was unmistakably of the Copper series has been seen which was not considerably tilted. The fact that certain sandstones belonging to the Copper series are very similar, if not lithologically identical with some of the Lower Silurian sandstones, has helped to complicate the question.

Subsequently he united with Hunt in the name Keweenawan for the traps and their associated amygdaloids and interstratified sandstones.† It will be noted that the use of the qualifying word "unmistakably," by Maj. Brooks, on each side of this dividing datum, in the classification which he adopts, leaves a wide margin of uncertainty. It is within this margin that the crucial facts on which such a distinction should rest, ought to be sought for; for on close inspection it might be found that, on either side, those strata which are assumed unmistakably to be one or the other, show characters of dip or other structural relations which would make them doubtful. Others might be doubtful on account of lithology. Thus the datum of distinction might disappear in thoroughly exploring the unknown interval of uncertainty existing between the unmis-

*Geological Survey of Michigan, vol. I, p. 185, 1873.

†Compare U. S. GRANT: The name of the copper-bearing rocks of lake Superior, AMERICAN GEOLOGIST, vol. XIV, pp. 192-194, March, 1895.

takable certainties to which he applies distinguishing names. This point will be examined more fully later.

Prof. Pumpelly's attention was given to the copper-bearing rocks and the sandstones. From his observations made on the Penokee and Gogebic ranges, and thence eastward to the Ontonagon river, in company with Maj. Brooks, he reached the conclusion that the Cupriferous series is conformable with the Huronian. A joint paper by Pumpelly and Brooks* expressed the opinion that the Cupriferous may be more nearly related, in point of time, to the Huronian than to the Silurian. Like Brooks, he calls the later sandstones Silurian, the Cambrian at that time being included in the lower part of the Silurian. From this conclusion, however, Brooks later receded† and pointed to evidences of the separateness of the Keweenawan and the Huronian.

Dr. Rominger affirms that there is no choice, from stratigraphic considerations based on observed facts, but to see in the Lake Superior sandstones the equivalent of the Potsdam sandstone. "Its lower portions are so intimately connected with the sandstones and conglomerate beds of the Copper-bearing trappean series that I could draw only an arbitrary division line between the two groups, which would swell the thickness of the sandstone group to many thousand feet."‡ In passing through the Portage canal, Keweenaw point, and to the west side of the axis of the point, Dr. Rominger made a series of careful observations upon the relations existing between the eastern sandstone and the western sandstone, and thence to the traps. He states that there seemed to be a conformable continuation in the descending order, "an uninterrupted serial connection between the trappean copper-bearing deposits and the Lake Superior sandstones." (P. 98.) This has never been contradicted as to that locality.

It appears, therefore, that the result of the Michigan survey, touching the relations of these sandstones to each other, and of the copper-bearing series to the Huronian, was not satisfactorily conclusive. The three principal geologists reached different conclusions. It remained for the Wisconsin

*Am. Jour. Sci., (3), vol. III, p, 428. 1872.

†Am. Jour. Sci., (3), vol. XI, pp. 206-211, 1876.

‡Michigan report, vol. I, p. 81 (of report on the Paleozoic rocks), 1873.

survey to put the stamp of approval upon one or the other of these diverging views.

Up to the time of the Wisconsin survey, therefore, it may be said that the following was the state of opinion of the leading official authorities on the geological questions under consideration:

1. The Huronian system is a vast congeries of Azoic fragmentals, cut by granitic and trappean eruptives.

2. The copper-bearing series overlies the Huronian, the upper volcanic group non-conformable on the original Huronian, and the lower volcanic group non-conformable on the expanded Huronian.

3. The upper volcanic group is non-conformable on the lower volcanic group.

4. The Cupriferous series (upper volcanic group), is closely associated with sandstones, the upper portions of which, and probably the lower, are of Potsdam age, the non-conformities with the traps being incidents of an eruptive age and of local extent and significance,—or

5. The horizontal sandstones are of wholly later date, of Potsdam age, and, being non-conformable against tilted trap, cannot be of the age of the trap.

[Palæontological Notes from Buchtel College. No. 11.]

ACTINOPHORUS CLARKI, NEWBERRY.

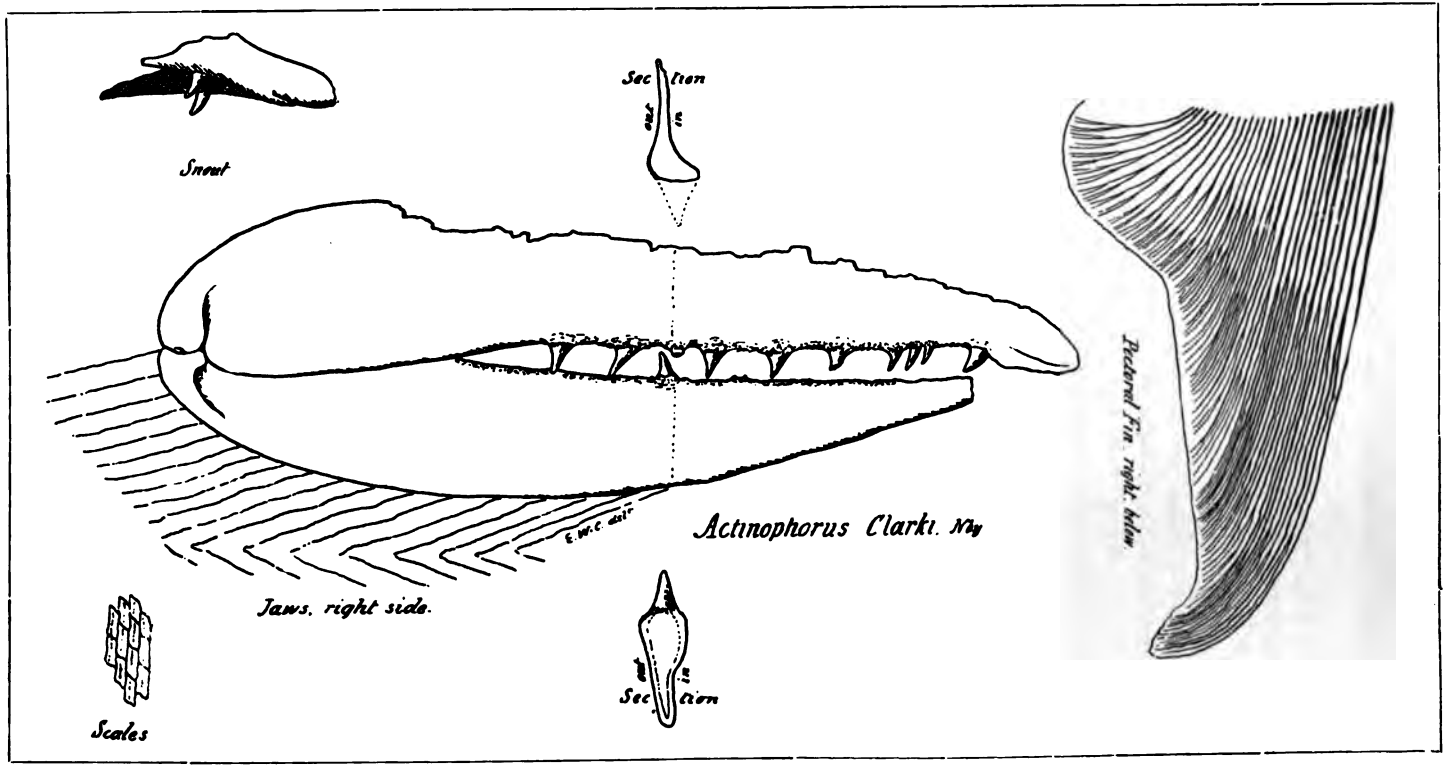
By E. W. Claypole, Akron, Ohio.

(Plate II.)

In his monograph of the fossil fishes of North America Dr. Newberry described and figured a specimen under the above name of which, however, very few details were given in consequence of the imperfection and indistinctness of the fossil. It was obtained by Dr. Clark of Berea, Ohio, from the Cleveland shale and is now in the collection of Columbia college.

Since that time Dr. Clark has found another specimen of the same fish which being in better condition, though incomplete, enables us to recognize some additional features. On this fossil the following note is based.

Actinophorus clarki was, according to Dr. Newberry's de-



ACTINOPHORUS CLARKI, NBY.

scription, about eighteen inches or two feet in length, but these measurements must be somewhat increased if we may judge by the size of the jaw of the new fossil which, when compared with that of Dr. Newberry's is at least one-third longer. The whole hinder part is missing, but the body is fairly preserved as far back as the ventral fins which are in part visible. The most conspicuous and the best preserved portions are the jaws and the pectoral fins. The jaws of the right side are almost perfect, lying closed and spread out on the stone. Those of the left side are crushed and concealed beneath them. The former aspect of the fossil is represented in our figure, where very little has been attempted in the way of restoration beyond supplying one or two teeth from the opposite jaw and setting in its original position the nasal or intermaxillary bone which had been flattened down.

The mandible in its general form agrees with that of the cladodont sharks as figured in one of our previous notes but it has little of the corrugation that is so conspicuous there and was consequently inferior in strength and stiffness though this lack was in part made up by a greater thickness. Its surface, in the hinder part at least, is marked with a fine and simple tuberculation. The broad thin blade of which posteriorly it consists thickens forward, especially upon its upper margin, so as to afford a broad base for the support of the teeth. Most of these have disappeared but one or two remain in place and resemble those of the upper jaw where most are still visible. They are simple, conical cusps, not true teeth, because they are not by nature epithelial but consist of integral parts of the jaw, as do the teeth of *Coccosteus*, being as it were excavated from that bone. Eight or ten of them stood in a row distant from each other about a half-inch and locked in, closing between those of the opposite jaw. Their form is that of a round cone slightly flattened laterally at the base. They are quite smooth and unstriated.

Behind these and along the upper margin of the mandible is an irregular row of small, fine, sharp denticles very distant from one another. They occupy about an inch and a half of the jaw and disappear where the maxillary closes down outside of the mandible. If they continue farther back they are concealed by this bone.

The mandible is nearly straight and meets its fellow of the opposite side at a very acute angle. The symphysis was not terminal but was overhung, as will be shown later, by the forward projection of the maxillary.

The maxillary also consists of a thin plate of bone of a similar nature and appearance to that of the mandible with which it unites posteriorly by a condyle fitting into a fossa or socket in the latter. The hinder part of this bone is in good condition but its anterior portion is badly crushed and displaced except along the edge that carried the teeth where it is well preserved. It bears the same style of ornamentation as the mandible already described and on its lower edge, between the condyle and the teeth, stood a row of fine, sharp denticles facing those already mentioned in the lower jaw. In front of these are six conical teeth, and three others can be supplied from analogy with the opposite maxillary, making nine in all. These in no wise differ from their antagonists in the mandible already spoken of. But in front of them and apparently rather in front also of the foremost of the lower teeth stand two very much larger and stronger than the rest. They are unfortunately somewhat forced out of place by the compression to which the fossil has been subjected, but they apparently inclined backward as well as downward, thus gaining additional prehensile power.

All the teeth are perfectly simple and show no sign of lateral denticles of any kind and of course no successional teeth are present.

The maxillary bones are firmly united in front and form a sharp beak or snout, projecting an inch beyond the above mentioned large teeth. All the rest of the head has been so crushed as to be quite unrecognizable, though some fragments of comparatively thick plates indicate the existence of an osseous cranium.

Along the lower edge of the mandible is a series of plates which were regarded by Dr. Newberry as representing the branchiostegal rays. He remarks "branchiostegal rays numerous" in his decription of the species. They are perhaps more correctly described by Mr. A. S. Woodward in his catalogue as a paired series of transversely elongated rays devel-

oped in the branchiostegal membrane between the mandibular rami.

These are an excellent preservation in the present specimen and form, as shown in the figure, a kind of fringe, composed of thin plates and covering the lower surface of the mouth, running backward from the lower margin of the mandible to meet on the median line a corresponding set from the opposite side.

The individual plates are about two inches long and one-third of an inch in width and overlap slightly at the edges. They are as thin as paper and apparently formed a pliable protection to the tissues beneath them. At the hinder end of the mandible these two sheets of chain armour parted on the medial line, leaving a space in which now lie the fragments of bone already mentioned, among which are probably the broken hyoids with some of the branchial arches in an unrecognizable condition.

Many of the above details are rendered attainable by the fact that, although the fish lies, as did that of Dr. Newberry, belly upward, yet the head has been so pressed to one side during fossilization as to show that aspect in considerable perfection. This has prevented the crushing of the semi-cartilaginous bones of the head into an indiscriminate mass as is usual with the fossil fishes from this shale.

Not much can be added to Dr. Newberry's account of the pectoral fins. They are well displayed in his specimen and only a few more details can be gathered from this one. The peculiar falcate form, the great number (68 in this case) and the remarkable thinness of the rays mark this species off from all other known fossil fishes of the same horizon. Both the long and the short rays fork at about one-third of their length from the base and again about as far from the tip so that their ultimate branches or trichinosts become excessively fine and give a very delicate texture to the edge of the fin which has no membranous border.

The scapulo-coracoid arch is only seen as a broken and crushed mass, so that it is impossible to give any account of it. It may, however, be noted that the pectoral fins show distinct signs of fulcra in the advance of the ganoid scales over the base of the rays in the hinder portion.

The pectoral fins are two inches behind the back of the mandible and about eleven inches farther back still may be seen parts of the two ventral fins. These show a similar fine structure and nineteen or twenty rays can be counted on one of the fragments.

No part of the body behind these fins is preserved in the specimen, so that its whole length can only be inferred from its proportions. But it was an exceedingly slender fish, not apparently exceeding three inches in width at the pectoral fins and one inch and a half at the ventral.

The skin was protected in whole or in part with a covering of small rhomboidal ganoid scales which are here and there preserved so as to exhibit their form and relationship. A few of them are shown, much magnified, in our figure. (Plate II.)

Though the present specimen affords several data concerning this fish that were not previously known, yet, unfortunately, its imperfection renders the determination of some other critical questions impossible. The whole head above the maxillary is missing, so that nothing can be said of the orbit or the suspensorium, on the position of which latter the place of the animal in the system in part depends. Its reference to the palæoniscids is, however, satisfactorily confirmed by other and previously known evidence, such as the minute scales, the broad and numerous branchiostegal rays and the very slender body. The genus was accordingly placed by Mr. A. S. Woodward next to his *Apateolepis* from New South Wales, a fish about ten inches long, whose length was about six times its greatest width.

Actinophorus clarki must have measured when alive at least thirty-six to forty inches while its greatest depth at the pectoral fins did not exceed three and a half or four inches, making the former dimension about ten times the latter and showing a fish far surpassing the other in slenderness and grace. *Apateolepis* is also said to be without fulcra, which, as we have seen, is not true of *Actinophorus*.

In the family of the Palæoniscids the neural arches are more or less ossified and in many cases the hæmal arches also, especially toward the caudal end. This is true of *Actinophorus*. A well marked line of thin bones can be traced from the pectoral to the ventral fins, a distance of fifteen inches. They

form a continuous ridge in the fossil and occupy about one-eighth of an inch each. These show by their position that they are the ossified neural arches and along the hinder part of the line a double row can be traced consisting of both neural and hæmal arches. The presence of distinctly ossified spines is not clear.

An interesting point in the interpretation of the fossil is the presence in the place of the stomach of the remains of the food. Behind the pectoral fin are the mandibles of a small titanichthyoid fish, with other unrecognizable plates scattered over the interval. Farther back still is a well marked ichthyodorulite fluted from end to end so far as it is visible. It lies separate from all the other fragments and must be regarded as belonging to the food and not to the fish in question. The original of neither of these relics has yet been discovered elsewhere.

The palæoniscids are an essentially Carboniferous and post-Carboniferous family of fishes, scarcely any of them having yet been found below the latter horizon, *Cheirolepis trailli* from the lower Old Red sandstone of Scotland and *C. canadensis* from the upper Devonian of Scaumenac bay, Canada, being almost the only Devonian forms. Moreover, it should be here borne in mind that this genus has been by some ichthyologists, as by Pander for example, separated from the palæoniscids and placed in a family by itself–the Cheirolepidæ.

It is, therefore, interesting to find so well marked a species of the family on an horizon so low and in company with as old a type as *Coccosteus*. The origin of the palæoniscids must evidently be sought in strata below the upper Devonian.

CAMPTONITES AND OTHER INTRUSIVES OF LAKE MEMPHREMAGOG.*

By VERNON F. MARSTERS, Indiana University, Bloomington, Ind.

*I wish to gratefully acknowledge assistance given by Mr. W. A. Wilson in providing me with a tracing from a map of lake Memphremagog on file in the office of the Canadian Geological Survey, and from which I have prepared the accompanying map (greatly reduced) showing the relative position of the dikes.

I desire also to express my sincere appreciation of assistance so cheerfully given by Mr. E. M. Kindle (instructor in Indiana University, 1893-94) and Mr. E. M. Walker, student, in collecting material under somewhat adverse circumstances.

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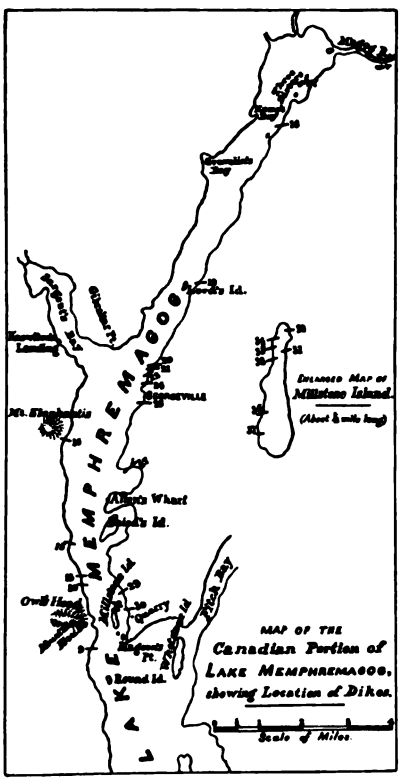
GENERAL STRATIGRAPHY OF THE LAKE SHORE.

In the northeast corner of Vermont and extending across the line into the province of Quebec for several miles is one of the most picturesque bodies of water to be found in that region. This unique lake has long been known as lake Memphremagog. It is somewhat crescentic in shape, but has a general north and south trend. The contour of the surrounding country and the shape and position of the lake, as compared with others in the same region, suggest that the depression now occupied by this body of water was produced by glacial agents. It is evidently not due to a downward folding of the Paleozoic strata, for there is little or no evidence of such a movement. On the other hand, the prominent elevations, especially those on the west side of the lake, as well as the shores, with their occasionally eroded surfaces, all point to the conclusion that the depression was produced by *glacial* erosion.

Along the southeastern shore there is sufficient accumulation of drift to render an examination of the country rock impossible. A few of the islands at the southern extremity of the lake are made up wholly of drift material, while those in the central parts consist of rounded domes of schistose and shaly rocks, having resisted to a remarkable degree the eroding effects of moving ice.

A brief examination of the stratified rocks, as exposed along the shores toward the north, has led the writer to believe that they represent the lower members of the Paleozoic. Starting from Magog, at the northern extremity of the lake, the rocks exposed on either side for some distance to the

south consist of thinly bedded shaly limestones. These extend on the west side as far south as Sargent's bay, and on the east within a short distance of Magoon's point. The three islands known as the "Three Sisters" show admirable exposures of the same limestone series, which is regarded as belonging to the Upper Silurian period. Passing to the south along the east shore a limestone formation was found to overlie a slaty series containing graptolitic remains. The slaty rocks are regarded by the Canadian Geological Survey as Cambro-Silurian. Between the graptolitic slates and the mouth of Fitch bay was found a schistose slaty deposit resting upon a crystalline series skirting the north shore of Fitch bay. The latter is regarded by Mr. Ells as pre-Cambrian,* being an extension of the Sherbrooke anticline which gives rise to Stooke mountain to the northeast. At Magoon's point were found moderately fine grained granites associated with schistose and slaty rocks. From this point to the southern extremity of the lake the country rock is quite extensively covered with drift. The granite is undoubtedly an outlier of the granitic series mapped by the Canadian Survey. Similar rocks cover quite large areas to the east and north.



The Upper Silurian limestones on the west were found to extend to the north side of the entrance to Sargent's bay.

*R. W. Ells, Report on the geology of a portion of the eastern townships, relating more especially to the counties of Compton, Stanstead, Beauce, Richmond and Wolfe. Can. Geol. Survey, Pt. J, An. Rep. 1886, p. 32.

On the south side of the bay similar shaly limestones were noted overlying a black calcareous rock. Further south the stratified rocks have been disturbed by the intrusion of Owl's head. The sediments are somewhat metamorphosed to calcareous schists and talcose slates. In this region calcareous layers were recognized *beneath* black slaty deposits, while on the east the calcareous rocks were found to invariably *overlie* the slates.* At Round island the rocks are made up wholly of calcareous schists intersected by dikes. These rocks are probably metamorphosed portions of Upper Silurian deposits.

The Dikes.

Through the entire area examined the dikes were found to cut the shaly limestones. It seems probable that the outlying dikes are more or less closely associated with the intrusions now represented by Owl's head, mount Orford, and possibly many others known to have occurred even as far north as Montreal. The dikes represent two well defined groups, *granites* and *lamprophyres*.

Granite Dikes.

The granitic intrusions are invariably light in color, owing to the predominance of quartz and white or flesh colored feldspar. The dark silicates consist mainly of biotite, with occasional flecks of muscovite, and yellowish brown patches of some mineral substance which has probably resulted from the decomposition of an iron-bearing silicate not at present recognizable. In some instances the crystalline texture becomes

*In a private letter Mr. R. W. Ells of the Canadian Geological Survey has kindly outlined the results derived from a recent study of the stratigraphy of this region. He says: "The lower part, as you suppose, is bordered on either side by Upper Silurian limestones which contain fossils at several points. These rocks extend from Capt. Gully's wharf, north of Magoon's point, to Magog, and on the west side from the north entrance of Sargent's bay to the north end of the lake. At Owl's head the Upper Silurian is underneath the Cambro-Silurian graptolitic slates, the formation being overturned. At Round island, below the Mountain house the rocks are Upper Silurian, fossiliferous, now altered to schists and cut by dikes from the Owl's head. This places the age of the Owl's head and other prominent hills in the vicinity at the same horizon as the Montreal intrusion or at the close of the Upper Silurian. The Owl's head dikes also cut the Cambro-Silurian slates as do the Orford diorites on the east. On the east side of the lake the Georgeville limestones are underlaid by the graptolitic slates about one and a half miles south of the village and the ridge between there and Fitch bay consists of an intermediate series, presumably Cambrian, between the graptolitic series and the pre-Cambrian of the extension of the Sherbrooke anticlinal.

unusually fine. The scales of biotite seem to have adjusted themselves in a parallel position as if the mass had been subjected to great pressure while in a plastic state. In such cases the rock presents a somewhat gneissic structure. In a few instances the dark colored silicates form but a small part of the rock, quartz phenocrysts become insignificant, and the crystalline texture is less prominent so that the rock mass at times resembles quite closely the bostonites* of lake Champlain. The rock ordinarily presents all the phases of a true granite and is regarded as such in this paper.

Lamprophyre Dikes.

There were found associated with the granitic rocks, as well as in other parts of the lake, dikes differing quite widely from the former, both in physical structure and mineral composition. Microscopic examination shows that they fall naturally into the lamprophyric group of Rosenbusch. They differ from the granites in being dark grey to black in color, with moderately fine crystalline texture and occasional phenocrysts of dark colored silicates, sufficiently well developed to be macroscopically determined. In some instances the phenocrysts were found to be pyroxene; in others the idiomorphic constituent proved to be hornblende; while in still other instances olivine played the same role. A number of instances were noted in which the olivine reached a diameter of one and a half inches. It is a significant fact that the olivine phenocrysts were invariably located in the central part of the intrusive mass. On the contact the dikes were generally fine-grained and in some instances even flinty, the phenocrysts having entirely disappeared.

Many of the olivine-bearing rocks have suffered decomposition. The olivine has passed into serpentine, thus imparting a peculiar green tinge to the rock. In some cases a cross section of the olivine crystals exhibit a central core of the original mineral surrounded by a coating or shell of serpentine. All stages of decomposition were found in the thin sections. No feldspar was macroscopically determined except in one or two undoubted diabases, which were evidently very

*Bull. No. 107, U. S. G. S., Trap Dikes of Lake Champlain, by J. F. Kemp and V. F. Marsters.

closely associated with the intrusive mass represented by Owl's head.

A microscopic examination of the dark colored rocks reveals some interesting petrographical relations. As was anticipated, the examination of the series proved them to be made up of the same mineral mixtures as were found along the shores of lake Champlain (Bull. 107, U. S. G. S.). The intrusives, therefore, as found along the shores of lake Memphremagog may be enumerated as follows: *Olivine diabase, camptonite, augite camptonite, fourchite* and *monchiquite.*

MICROSCOPIC DESCRIPTION OF DIKES.

Granite Dikes.

This variety predominates along the eastern shore of the lake immediately north of the mouth of Fitch bay. A few narrow dikes were also found intersecting an island opposite Owl's head.

Thin sections revealed well developed phenocrysts of feldspar, as well as exceedingly minute lath shaped crystals, the latter making up at least eighty per cent. of the rock and constituting the ground mass. In some cases the ground mass has suffered mechanical deformation, thus inducing an apparent *clastic* structure. When the clastic magma prevails the feldspar phenocrysts become comparatively rare. When the micro-crystalline structure predominates the porphyritic feldspars become prominent and generally show twinning structure.

Quartz occurs as large irregular grains showing little or no crystalline form, and as fine grains making up a portion of the ground-mass. The larger individuals contain numerous streaks and clouds of fine dust, probably magnetite, as well as minute hair-like crystals with high index of refraction. Cross sections show hexagonal outlines. The crystalline form and high refraction suggest that the inclusions may be apatite. Under a high power lens numerous globules and acicular aggregates were also detected.

Mica is the only remaining constituent of any importance. Biotite is by far the most prominent, but a few flecks of muscovite have been detected in one or two sections. The biotite occurs as large irregular plates or bunches. The larger flecks are invariably frayed out on the edges as if they had been

subjected to some eroding process. It seems probable that the more minute flecks and shreds of biotite found in the ground mass may have been derived from the larger individuals which originally may have been idiomorphic. Pleochroism is especially prominent. Plates parallel with the cleavage show a bright brown to very dark brown or nearly black color, while sections across the cleavage exhibit lighter shades of brown with a yellow tinge, and upon rotating the stage becomes dark greenish yellow. The biotite is generally quite fresh but in a few instances a partial decomposition to a reddish opaque mass was noted. Small amounts of magnetite are present with the biotite in addition to the fine dust noted in the quartz grains.

Lamprophyre Dikes.

While a few of the dark colored intrusives are undoubtedly diabase the majority of occurrences show various porphyritic constituents which even by an examination of the hand specimens led me to anticipate the repetition of the same mineral mixtures (monchiquite group of Rosenbusch) as were found on the borders of lake Champlain to the southwest. As was expected microscopic examination reveals all the varieties of the monchiquite group except the biotite-amphibole mixture designated by J. F. Kemp as amphibole ouachitite.*

Diabase.—The true diabases differ much from the typical diabases of the Triassic trap-ridges of the Hudson river or similar flows forming the north mountains of Nova Scotia. The dikes under consideration differ in containing a much smaller percentage of lath-shaped feldspar and a correspondingly large amount of augite, with occasional olivine phenocrysts. Ophitic structure, so common in the Triassic diabases of Nova Scotia, is quite generally absent in thin sections. The augite proves to be the most prominent colored silicate present. It occurs in two generations, as phenocrysts and as irregular grains making up a portion of the groundmass and partially filling the interstices between the feldspars. The porphyritic form is well developed, showing in cross section the characteristic cleavage angle and crystalline form. In most instances they exhibit light yellow rims with slight

*Ark. Geol. Survey, vol. II, p. 393, 1890. Basic dikes outside of the syenite areas of Arkansas.

pleochroism and a still lighter yellow or nearly colorless centers with little or no pleochroic tendencies. Rims of magnetite and reddish opaque masses generally surround the larger individuals and in a few cases seem to be partially absorbed by the peripheral area of the phenocryst. The irregular grains of the ground-mass have undergone more or less decomposition giving rise to secondary products. The grains as in the case of the phenocrysts are generally surrounded by magnetite rims or have become opaque and gray in color.

Olivine is also more prominent than in the typical diabases. It is present as large crystals which have suffered greater change than its host. Fibrous rims and patches of serpentine make up the secondary products derived from the olivine.

Plagioclase forms the remaining part of the rock. The crystals are invariably fresh and lath-shaped, but not large. Multiple twinning is very common. An arrangement akin to flow-structure, or an adjustment of the individual feldspars, in a more or less definite direction, is apparent in a few sections. Pockets or cavities filled with calcite are quite numerous in some sections. In some cases they were lined with a fibrous mineral resembling serpentine, thus suggesting that the original mineral substance may have been olivine. On account of the prominence of olivine the rock is regarded as an *olivine diabase*. No. 17 is the best representative of this type. Others were found but are so completely weathered as to be unfit for microscopic study.

Camptonite.—Associated with augite plagioclase rocks were found other mixtures of hornblende, augite, olivine and plagioclase. In two dikes the olivine and augite disappear, leaving the hornblende and plagioclase as the chief constituents. This combination is regarded as the typical camptonite. The hornblende is always of the basaltic type, idiomorphic and in two generations. In a few dikes the augite forms an appreciable part of the rock, and in some instances is more prominent than the hornblende. Comparing these with the camptonites of lake Champlain, it is evident that the persistent association of augite with the basaltic hornblende, together with its larger growth and idiomorphic habit, is more prominent in the lake Memphremagog occurrences. Owing to this

fact it is thought best to regard this combination as *augite camptonite.*

No. 20. Of the typical camptonites but one occurrence was found, (No. 20). In this dike the basaltic hornblende in two generations is the only colored silicate present. Magnetite is very abundant. The amount of plagioclase present is not large, but it is quite fresh. Considerable glass was also detected in the groundmass. Comparing this section with the original camptonite* discovered by Hawes, the only difference to be noted is that the hornblende is not so well developed in the dikes from lake Memphremagog. Although they are much smaller the idiomorphic habit is quite apparent and other petrographical characteristics of this type are very easily recognized.

Augite camptonite.—Of all the dikes belonging to the camptonite series the augitic type is by far the most abundant. In addition to this hornblende in two generations, we find augite in the same relationship. In many cases the augite is far more abundant than the hornblende. The idiomorphic habit of the hornblende is retained as in the camptonite proper. The augite phenocrysts are well developed. The zonal phases so prominent in the Lake Champlain† dikes are equally conspicuous in the dikes under consideration, the central portion of the individual being in general very light yellow while the peripheral area shades into light pink which brightens as the edge is approached, the latter being somewhat pleochroic. Occasionally the central part is bright green surrounding a narrow rim, light yellow in color. It has been noted that with increase in the intensity of color in the peripheral area there is a corresponding increase in the extinction angle. The variations noted reach a mamimum of 8°.

The augite of the second generation shows definite crystalline form. It is packed in between the feldspars and is the only granular constituent present. Pleochroism is noticeable. Small olivines with characteristic form and decomposition

*The author wishes to acknowledge the aid so kindly rendered by Prof. J. F. Kemp, of Columbia College, N. Y., in loaning thin sections of camptonite from the original locality of Hawes, and offering suggestions which have been very helpful in the study of these intrusives.

†See Bull. U. S. Geol. Survey, No. 107, p. 30.

products were observed in a few sections. Although considerable plagioclase is present it is decidedly secondary in amount to the colored silicates. The idiomorphic habit so evident in the diabases has disappeared, but the lath-shaped form and twinning are very easily recognized. Dikes Nos. 12, 14, 19, 24, 27, 34 are augite camptonites.

No. 12. Augite is the chief colored silicate in this dike. Two generations are present. The phenocrysts exhibit marked zonal structure, the centres being nearly colorless or light shades of yellow or green, and rims various shades of pink with slight pleochroism. In general, it may be said that the greater variation in color the stronger the pleochroism. The augite of the second generation is allotriomorphic with the same optical features as the porphyritic constituent and filling the interstices between the plagioclases. The hornblende present is very small in amount. Only a few flakes and ragged blades were noted. The plagioclase, although quite subordinate, shows the usual twinning and bladed form. Olivine crystals and grains are not uncommon. Serpentine is more or less closely associated with the olivine. Magnetite is also quite abundant.

No. 14 differs from No. 12 in containing more hornblende, but it is still secondary in amount to the augite. Only one generation of hornblende is present and it is aggregated in bunches throughout the section. The individuals are idiomorphic and highly pleochroic, bright yellowish brown to deep brown. Cross-sections show the following forms: ∞P, $\infty P\bar{\infty}$, $\infty P\infty'$. Augite in two generations forms the larger part of the rock. The phenocrysts are exceptionally well developed, showing excellent zonal structure in nearly every individual, the centers being light yellow or colorless and the rims bright yellow with slight pleochroism. In cross-section the following faces are easily recognized: $\infty P\bar{\infty}$, $\infty P\infty'$, ∞P. The following angles were determined by means of the graduated stage: $I \wedge I = 88°$; $ii \wedge I = 132°$. Very little fresh olivine was recognized. The larger phenocrysts have passed into serpentine, the crystalline outline, however, being retained. The plagioclase is generally twinned and more abundant than in No. 12. The feldspar contains numerous inclusions of colorless needles with strong refractive

power as well as minute and ragged flecks of a brown pleochroic mineral resembling hornblende. The former may be apatite. Irregular bunches of magnetite are exceedingly abundant.

No. 19 is nearly identical with No. 14, with the exception that the augite phenocrysts generally show a smaller extinction angle. The great portion of the interior is grass green to yellowish green with yellow to pink rims. Small inclusions of hornblende were observed in the augite.

No. 24. In this section the colored silicates show the same relationships as in No. 19. The plagioclase however is unique. It is more abundant than in any section yet described and contains the usual inclusions. The individual crystals are arranged with the long axes in the same general direction. The fractured and bent shape suggests that such an adjustment of the individuals may have been caused by great pressure while the magma, although somewhat plastic, was sufficiently firm to suffer fracture. This section is an interesting one for the reason that it contains pockets of a green opaque mineral in which are distributed many fresh basaltic hornblendes. The hornblende too is chiefly confined to this part, very little being associated with the augite.

No. 27. The description of No. 12 is quite applicable to No. 27 with the exception that there is relatively much more augite of the second generation and correspondingly fewer augite phenocrysts of the first generation.

No. 34 agrees very closely with No. 19, with olivine as an additional constituent. The olivines are unusually well developed, and are easily recognized in the hand specimen, some of them being fully one and a half inches in length.

Summary of Literature on other Occurrences of Camptonite.

The name camptonite was first applied by H. Rosenbusch* to dikes containing augite and basaltic hornblende as the chief bisilicates, with variable percentage of plagioclase, magnetite and accessories. G. W. Hawes† was the first to discover these peculiar rocks in this country, near Campton, N.

*H. Rosenbusch: Physiographie der massigen Gesteine, vol. i, 1886, p. 333.

†G. W. Hawes: On a group of dissimilar eruptive rocks at Campton, N. H. A. J. S., (3), vol. xvii, p. 14, 1879.

H., but described them simply as diabase, olivine-diabase and diorite. I apprehend it was to material from this locality that Rosenbusch first applied the term camptonite, as the name implies. Subsequently similar rocks found in the vicinity of Montreal were described by B. J. Harrington. In 1888 J. F. Kemp* discovered other occurrences in Orange county, N. Y. In 1889 the same writer§ described another camptonite dike from Kennebunkport, Maine, and in the same year (as joint author with the present writer) published a short description of identical intrusives from Whitehall,‖ N. Y. and Proctor, Vt. In 1890-91 a much larger number of camptonite dikes were discovered along the shores of lake Champlain by the same writers.¶ An additional occurrence some thirty miles east of Fairhaven has been noted by Mr. F. L. Nason.** But few occurrences have been noted in other countries. E. Goller†† describes very similar rocks from the Black forest; Cathrein‡‡ and Doelter§§ make mention of one from the Southern Tyrol, and Brögger‖‖ of others from Norway.

Monchiquite Dikes.

In dike No. 16 the feldspar disappears—pyroxene and amphibole become very prominent, making at least 80 per cent. of the rock. Olivine and its decomposition products play an important role. The importance of the individual constituents based upon relative amounts composing the rock is as follows: Augite (second generation), augite (first generation), basaltic hornblende, olivine, magnetite.

*J. F. Kemp: Diorite dike from the Forest of Dean, Orange Co., N. Y. A. J. S., (3), vol. xxxv, p. 331.

§J. F. Kemp: Trap Dikes near Kennebunkport, Me. Am. Geol., Mar., 1890, p. 127.

‖J. F. Kemp and V. F. Marsters: Camptonite Dikes near Whitehall, Washington Co., N. Y. and Proctor, Vt. Am. Geol., 1889, p. 97.

¶J. F. Kemp and V. F. Marsters: The Trap Dikes of the Lake Champlain Region. Bull. U. S. G. S. No. 107, 1893.

**F. L. Nason: On a new locality for the Camptonite of Hawes and Rosenbusch. A. J. S., (3), vol. xxxviii, p. 229, 1889.

††E. Goller: Die Lamprophyrgänge des südlichen Vospersart. Neues Jahrbuch, vol. vi, Beil. Band 1888, p. 485.

‡‡A. Cathrein: Zeitschr. f. Krystal., vol. x, 1884, p. 221.

§§C. Doelter: Tscher. Min. und Petrog. Mitth., 1875, pp. 179, 188 and 304.

‖‖W. C. Brögger: Zeitschr. f. Krystal., vol. xvi, 1890, p. 23.

The augite phenocrysts present the same characteristics as observed in the augite camptonite. It might be said in addition that the zonal structure is somewhat more prominent, becoming intensified under cross nicols. The angle of extinction varies from 20° to 24°. The augite of the second generation which makes up the greater part of the ground mass is allotriomorphic, with a tendency at times to become idiomorphic. Scattered through the augitic magma are numerous but minute crystals of basaltic hornblende. The strong pleochroism from light yellow to deep reddish brown is especially noticeable. With one or two exceptions the hornblende may be said to show but one generation. A few very minute needles, however, were noted as inclusion in the augite phenocrysts. The remaining silicate is olivine, occurring either as partially decomposed granules, surrounded by rims of serpentine, or, occasionally as well developed phenocrysts exhibiting the usual crystalline form. Magnetite is very abundant and closely associated with the augitic groundmass. Considerable glass was observed filling the minute interstices in the groundmass.

Summary of Literature on Other Occurrences of Monchiquite.

Such non-feldspathic rocks were first discovered by Prof. Bonnet* in the Monchique mountains (Portugal) and subsequently described by Leopold van Werweke† as an abnormal limburgite. In 1887 Prof. E. O. Derby‡ of the Brazilian Geological Survey discovered similar eruptives in the region of Rio Janeiro. These, as in other instances, were associated with eleolite syenite. They were subsequently examined by Prof. Rosenbusch§ and in reality formed the basis for the determination of the new rock type, but received the name of the original locality discovered about 1850. Along the shores of lake Champlain very similar dikes were found and subse-

*Algarve Bonnet: Description geographique et géologique de cette province. Lisbon, 1850.

†L. v. Werweke: Beitrag zur Kenntniss der Limburgite. Neues Jahrbuch, 1879, p. 481. See also Neues Jahrbuch, 1880, vol. i. pp. 141-186. Ueber die Nephelin syeniten der Serra de Monchique im südlichen Portugal und die denselben durchsetzenden Gesteine.

‡O. A. Derby: On Nepheline Rocks in Brazil, etc. Quart. Journ. Geol. Soc. London, 1887, p. 457.

§M. Hunter and H. Rosenbusch: Ueber Monchiquite ein Camptonitisches Gangestein aus der Gefolgschaft der Elaeolith-syenite. Tschermaks Min. und Petrog. Mitth., vol. xi, 1890, p. 445.

quently described by Prof. J. F. Kemp and the writer.* J. Francis Williams† has also contributed to the annual reports of the Geological Survey of Arkansas very elaborate petrographical investigations of similar intrusives found in the vicinity of Fourche mountain, Arkansas. In this locality were found all the members of the monchiquite group. In defining the petrographical features of the monchiquites Dr. Williams states that "Rosenbusch considers these are made up of a porphyritic combination of olivine, augite and a glassy base with which may be associated either hornblende or mica or both of these minerals together. The glassy base often includes minute crystals of plagioclase and occasionally of nepheline."

FOURCHITE DIKES.

In dikes Nos. 18 and 40, olivine, forming one of the essential constituents of monchiquite, entirely recedes, thus producing an olivine-free monchiquite. To such a mineral mixture J. Francis Williams has given the name *fourchite.*‡

The dike under consideration is composed chiefly of basaltic hornblende in two generations with a very subordinate amount of augite, a moderate amount of magnetite and a glassy base. The older hornblende phenocrysts are universally large, well terminated and beautifully pleochroic. The smaller circular forms show the same feature as noted in the camptonites proper. Of the two generations the latter is more abundant. Augite is very subordinate, consisting of a few poorly developed individuals and occasionally pink or yellow grains in a glassy base. Imbedded in the glass are many minute highly refracting needles. These may be apatite. A dark grayish opaque mass seems to be associated with the allotriomorphic augite. It may have resulted from the decomposition of augite, and may thus account for the unusually subordinate position of this mineral species. Much magnetite is also present.

In the region of Fourche mountain, Arkansas, Dr. Williams found numerous dikes of very similar mineralogical composition. In these occurrences, however, augite seems to be the most prominent constituent, while hornblende is more

*Op. cit.

†J. FRANCIS WILLIAMS: Igneous Rocks of Ark. Annual Report, Geol. Survey of Arkansas, 1890, vol. II.

‡See Ann. Rep. Geol. Survey of Ark., vol. II, 1890, p. 110.

or less subordinate. The reverse is true of the occurrences under consideration. In the Lake Champlain region but one dike that can with any degree of certainty be called fourchite was found. Strangely enough, not a single dike, so far as I have examined them, shows a trace of biotite, which forms an additional and essential constituent of the missing member of the monchiquite group. The same is true of the Lake Champlain dikes. To such a combination Prof. J. F. Kemp has applied the term *ouachitite.**

Other dikes than those mentioned are known in the region north and east of the lake. Prof. Kemp reports one from Sherbrooke. It therefore seems probable that a careful examination of the lakes, streams and elevated areas between Magog and the St. Lawrence river may bring to light many more of these interesting formations.

THE KAME-MORAINE AT ROCHESTER, N. Y.†

By H. L. Fairchild, Rochester, N. Y.

[Plate III.]

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Introduction.

The city of Rochester is situated upon a plain having an average altitude of 500 feet above ocean level. Within a ra-

*The classification of this series, as arranged by H. Rosenbusch, and presented in tabulated form by Dr. Williams, in his Arkansas Report, p. 110, is as follows:

Monchiquite Group. (Rosenbusch, 1890.)

Containing Olivine.	Glassy base and minerals	Olivine free.
Monchiquite, Rosenbusch, 1890	Augite	Fourchite, J. F. Williams, 1890. Augitite from Sierra de Tingua (in part), Rosenbusch.
Amphibole monchiquite	Amphibole and augite	Amphibole fourchite.
Biotite monchiquite	Biotite and augite	Ouachitite, Kemp, 1890.
Amphibole biotite monchiquite	Amphibole, biotite and augite	Amphibole ouachitite.

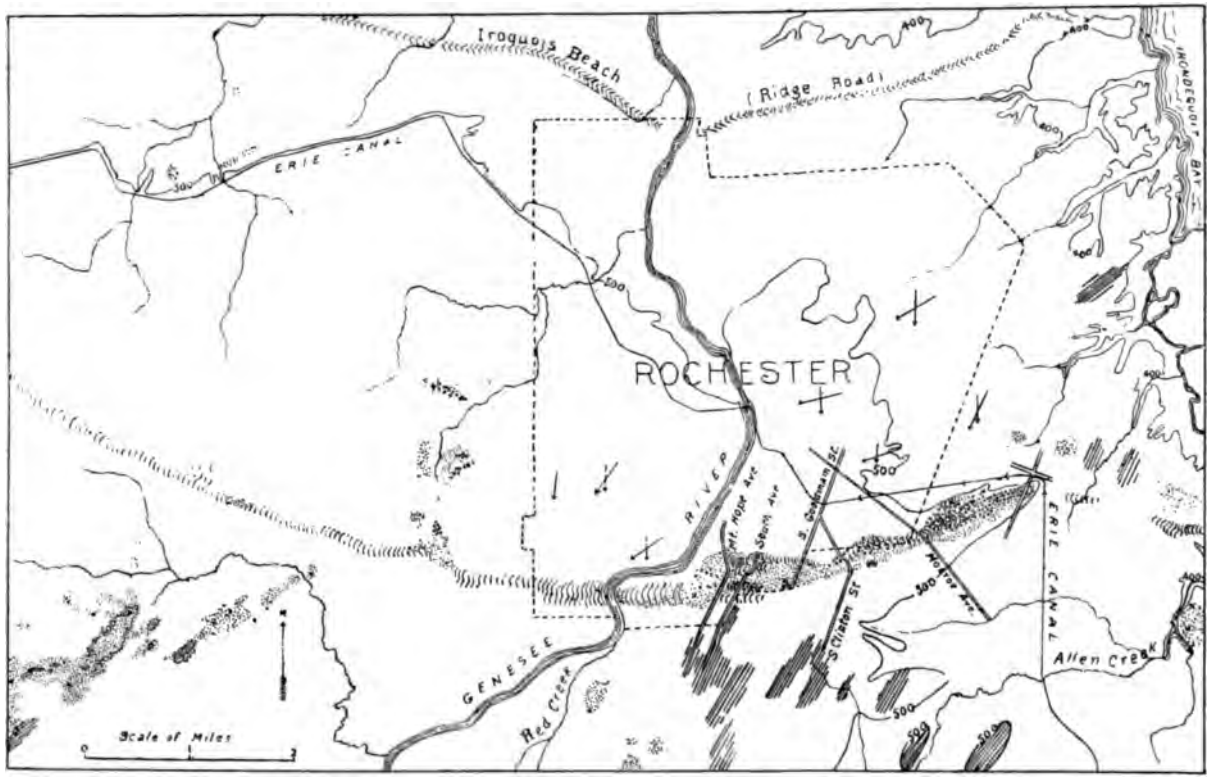
†This paper is an abstract of a longer and more complete description of the "Geology of the Pinnacle Hills," read before the Rochester Academy of Science, April 22, 1895, which will be published in the Proceedings of that Society, with maps and photographs.

dius of six miles from the center of the city the only elevations even one hundred feet higher than the plain are the range of hills known as the "Pinnacle hills," lying at the south border of the city. With their conspicuous position, unusual topography and complex structure these hills have not escaped the notice of glacial geologists, but until 1892 no one ventured any detailed description or any explanation of their origin.* During the meetings of the Geological Society of America and the American Association for the Advancement of Science in Rochester, August, 1892, the geologists in attendance visited and subsequently discussed them briefly in "Section E." At the Ottawa meeting of the Geological Society in December of that year Mr. Warren Upham read a paper describing these and other deposits of the region under the title "Eskers near Rochester, N. Y.," which was subsequently published in the Proceedings of the Rochester Academy of Science.† In that paper Mr. Upham describes the hills with considerable detail and concludes that they were deposited "in the ice-walled channel of a stream of water," "open to the sky." Since that time the writer has been able to make a long and close study of these peculiar hills and has been forced to a conclusion radically different from that of his friend, Mr. Upham. The opinion as to their origin, which the writer holds with full confidence, is that the hills are a kame series forming part of a frontal moraine. (See Plate III.)

Mr. Upham's brief examination of the hills was made under the disadvantages that the forests were in full leaf and the gravel pits in active working. Only when the thick timber and undergrowth which covers the roughest portions are bare of foliage does some of the most significant topography appear to good advantage; and the structure of the finer sands is developed by the wind only when the walls of the pit are

*The earliest published reference to these hills is in Dr. James Hall's report on the Fourth Geological District of New York. Professor Chester Dewey recognized their glacial character, so the writer is informed, but no writing of his relating to them has been found. In the AMERICAN GEOLOGIST, vol. v, p. 202-207, April, 1890, Dr. Charles R. Dryer, in an article upon the "Glacial Geology of the Irondequoit Region," refers briefly to the hills.

†Vol. II, pp. 181-200, February, 1893.



SALIENT FEATURES IN THE GLACIAL GEOLOGY OF ROCHESTER, N. Y.

left undisturbed for some time, yet not so long as to crumble. Mr. Upham is mistaken in describing the hills as a "ridge," and he seriously underestimated the amount of till in their mass and the great amount of disturbance to which the beds have been subjected. Several important characters which are not noted in Mr. Upham's paper will be briefly described in the following pages.

Location and Grouping of the Hills.

The Pinnacle hills extend from the village of Brighton to the Genesee river, a distance of four miles, with a general direction of west 15° south. The belt of hills has a linear form with a distinct curvature of large radius, the convexity facing southward. The range, however, is not continuous or uniform, but consists of groups of irregular hills and knolls, three main divisions being easily recognized. The first large group extends from Brighton to Monroe avenue. This group is subdivided by a deep cut, the western mass being known as Cobb's hill, with a summit hight of 663 feet above tide. The sag which was cut by Monroe avenue originally had an elevation of 560 feet. The second large group lies between Monroe avenue and a sag or depression one-fourth of a mile west of South Clinton street (Pinnacle avenue). This group is the most distinct and compact, and contains the highest point in the whole range, called the "Pinnacle," which name has been extended to cover the whole series of hills. The altitude of this summit is 749 feet, or about 240 feet above the surrounding plain. The third group may be regarded as including all the western part of the hill range, which is lower than the eastern part, much broader and less definite. This includes in succession, westwardly, the knolls east of South Goodman street; Highland park, between Goodman street and South avenue; the "Warner tract," lying between South and Mt. Hope avenues; Mt. Hope cemetery, lying west of Mt. Hope avenue; and the low point running into a bend of the Genesee river. The highest points in this area are the knoll on which is built the Memorial pavilion, near the reservoir, 650 feet, and summits in the cemetery, 650 to 670 feet.

Topography.

The eastern portion of the range consists of a series of overlapping ridges or elongated mounds having their longer diameters parallel in general with the trend of the range. Only at the "Pinnacle" is the cross-section a single ridge, and this part is better described as an elongated, irregular mound. The width of the belt at Cobb's hill is but little less than one-half mile, and here the crests of the northern and southern series of ridges or mounds are about one-fourth mile apart. At South Goodman street the two series of ridges are one-eighth of a mile apart. The western third of the range, or the portion beyond South Goodman street, is very different, being, instead of east-west ridges, a broader, irregular aggregation of mounds with a larger number of enclosed basins.

The crest line is very irregular, nowhere level for any distance, varying 100 to 180 feet in hight between the groups of hills. The northern slopes of the range are irregular, with spurs and hillocks and deep ravines, and over the eastern half of the range are usually as steep as the material will rest, 25 to 30 degrees. The southern slopes are more smooth and uniform, commonly with gentle inclination to the southern plain into which they blend.

The irregularity of the hills is great in both longitudinal and transverse sections. The only feature of evident system is the linear arrangement of the series, taken as a whole.

A striking feature which has not been sufficiently noted is the frequent occurrence of "kettle holes" and basins. A better example of mound and basin topography might not be desired than is found in Mt. Hope cemetery. Beautiful examples of kettle holes are seen here; also in the Warner tract; also east of South Goodman street, and east of Cobb's hill. The only ponds or swamps are found east of South Goodman street, where one pond occurs, lying at the base of the hills, and one large oval basin has been filled with peat to a depth of at least six feet.

Structure and Composition.

The materials composing these hills are so various and with such irregular arrangement that a brief description is difficult and inadequate. A minor portion is true till, which forms a thick sheet over Cobb's hill and probably the very summit

of the Pinnacle. The flanking ridges and knobs along the north side are mostly till, and one till ridge is found with east and west direction upon the south side of the range at South avenue. Gravelly till is abundant along South avenue and in Highland park. Huge blocks of Niagara limestone abound upon the Pinnacle summit and in many other places, and occur in prodigious numbers in the till covering Cobb's hill, mostly angular, although many are heavily scored and striated. The till is probably sufficient in amount to constitute alone a distinct moraine.

The greater mass of material is sand and gravel, of all sizes up to large cobbles, and of every admixture. The coarser material is not well assorted and the stratification is usually obscure, except in the mass and in a distant or general view. More than one-half of the coarser material is Medina sandstone, which also constitutes the mass of the sand and gives a reddish color to even the finer sand and silt.

In a broad way it may be said that the coarser materials prevail at the eastern end of the range and finer gravel and sand at the western end; but there are notable exceptions. The large pit in the heart of the north ridge near Brighton is mainly sand and silt. The great pit on the south side of the "Pinnacle," reaching almost to the very core of the hill and exposing a full 100 feet vertical section, is nearly all fine gravel. At South Goodman street the cutting for the grade, with the deep sewer tunnel below, shows fine sand and silt, with only thin leaves of fine gravel, to a depth of 72 feet. In Mt. Hope cemetery heavy gravel beds occur, while the low point near the river, cut by the railroad, is chiefly till with a jumbled mixture of sand and silt. It is the general rule that the coarser beds are upon the northern side of the hills, while the southern side is usually fine sand horizontally bedded and undisturbed.

The dip of the beds is not westward nor lengthwise of the hill range, nor is it away from a median line, as would be the case if the range were an esker, but generally southward and east of south, or across the trend line. This southward dip is most pronounced in the gravels upon the north side of the hills. At the extreme east end, near Brighton, the gravel dips in several directions from the end of the ridge. In the huge

Pinnacle pit, 80 feet thickness of the lower gravel beds in the heart of the hill have a dip of 12°-15° to east or south of east. There are many local exceptions to the southward or east-of-south dip of the coarser beds, and some small sections show inclination in several and even opposite directions. Obviously a part of this local variation is due to disturbances by the ice thrust. Some of the diverse inclination may be due to original deposition in subaqueous cones by the changing torrents of water over an ice front subject to every possible variation. Where beds of fine sand and silt are steeply inclined the inclination may be wholly attributed to ice thrust.

At two localities upon the south side of the range, one upon Goodman street and the other east of South Clinton street, distinctly bedded and alternating sands and gravel have a high dip to east of south. At the former pit the dip is 10°-14° to S. 15°-30° E. At the latter excavation the dip is 20° to east, varying to south. These beds show no disturbance, but are filled with angular and glaciated stones of large size.

Upon the north flank of the hills and even to the heart and summit, as shown at Monroe avenue and at South Clinton street, the beds have suffered great disturbance. This is shown in the coarse gravel beds by the loss of all stratification, and in the fine gravel, sands and silts by their tumbled, tumultuous, disordered character. In all the pits there is much faulting. This is the chief kind of disturbance in the deeper parts of the hills, and in some sections it is truly surprising.

The sand beds upon the south flank of the hills have an approximately horizontal position and are without faulting or other disturbance. The structure of the beds indicates currents sometimes westward, or parallel with the range, sometimes west of south, or obliquely across the range, and sometimes east of south, or more directly across the trend of the range. The large sand pit near Brighton shows current lamination in the fine sands and silts produced by flow of water varying from east to south. The heavy beds of fine sand south of Cobb's hill show currents S. 45°-60° W. The deep cut on Goodman street reveals a direction of current west of south.

The structure of the hills would seem to be explained by

supposing them to have been built up from several centers of accumulation by shifting torrential streams pouring over a changing ice front.

MORAINIC CHARACTER AND RELATIONSHIP.

The topography of the whole range is decidedly morainic. Of this there can be no doubt. The origin of the range as a frontal moraine requires, however, its continuance both east and west, and the evidence of such continuation is abundantly at hand. Eastward from Brighton the ice front has left its marks in the form of boulder-fields and low ridges and mounds of till and sand, until intercepted by the deep excavation and drainage of Irondequoit bay. East of Irondequoit bay conspicuous boulder-fields of huge Niagara blocks, piled in great masses, mark the further eastward extension of the ice front. West of the Genesee river for two miles the moraine is plainly continued in knolls and ridges of till, as noted by Mr. Upham. The further extension of the moraine westward was first discovered by Mr. Frank Leverett, in 1893. He traced it as a low but distinct frontal moraine from near Albion and Brockport southeastward to the Genesee river opposite Mount Hope cemetery. Relying, however, upon Mr. Upham's theory that the Pinnacle range was an esker, formed at right angles to the ice front, Mr. Leverett sought for the continuation of the moraine in a low, broad, indefinite ridge of till, running southward from Mt. Hope, which is probably drumlinoid. The distinct curvature of the Pinnacle range is now seen to be of great significance, as it forms part of the arc described by the front of the glacier lobe. The accompanying map (Plate III) shows the moraine west of the Genesee river and its continuation in the same curvature as the kame series of the Pinnacle hills. As remarked above, the amount of till in the hills would probably be sufficient in itself to mark a distinct continuation of the undoubted moraine.

The glaciated surface of the Niagara limestone beneath Rochester is found to have over the main and older striæ, with their direction of S. 40°-60°W., another lighter and later striation, hardly more than a polishing, with direction perpendicular to the arc of the moraine. West of the Genesee river the last ice movement was S. 5°-15°W., as shown in sev-

eral localities. East of the river exposures are rare, but the few found give a direction east of south for the latest striæ.

Conditions of Formation.

The changes from fine to coarse material in a direction lengthwise of the range of hills are too abrupt, too complete, and too frequent for production by a single continuous river. Objections to such agency are also found in the irregularity of the topography; the inclination of the strata; the direction of current lamination; the distribution of the materials according to size; and the extreme difference between the north and the south slopes. Every one of these features, along with the topography, the distribution of till, and the pushing of the northern sides of the hills, is entirely explained by supposing the beds to have been accumulated at the front of the ice sheet by the drainage from the dissolving glacier. One other condition is necessary to account for the peculiar structure, and that is a body of deep water into which the materials were thrown. It was the recognition of this condition that gave the writer the key to the problem.

At the time when the Ontario ice-lobe deployed over the Rochester plain, the eastern or Mohawk outlet of the glacial waters must have been still closed by the Adirondack ice-sheet. The waters of lake Warren laved the front of the Rochester glacier to a depth between 350 and 400 feet. The evidences of this deep water through western-central New York are abundant and conclusive. The discussion of this subject will form another paper. To the writer it seems clear that the "Pinnacle hills" are a true kame series, forming part of the frontal moraine of the water-laved glacier.

Over the flat area south of the kame hills thick silts and brick clays lie above the till, which are the finest deposit carried out into the lake by the slackened currents of the glacial rivers. North of the range the silts lie thick in the depressions of the plain, as the waters of lake Warren doubtless buried the region for some time after the retreating ice-front had abandoned the locality.

An objection to the morainic origin of the hills might be offered, that the accumulation of such a mass of assorted materials along three miles of the ice-front seems inconsistent with the diverging flow of the glacial streams, and more ex-

plicable as the result of the concentration of the torrential waters in one channel. This objection may be answered by a discussion of the peculiar conditions, and a description of other kame areas of the region.

The total amount of stream detritus in these hills may not be so great, comparatively, but it shows to full advantage because it lies conspicuously upon a plain, instead of filling depressions in an uneven surface.

The Pinnacle hills are only a small portion of the enormous amount of water detritus which the glacial drainage has left over the Genesee and Irondequoit region. The objection above noted would apply to other deposits of even greater magnitude. In a recent journey through the Genesee valley professor Shaler noted the unusual and remarkable amount of water deposits, which even occur frequently upon the drumlinoids throughout Monroe county and adjacent territory. In explanation it should be noted that the strata outcropping north of Rochester are peculiarly adapted to supply the finer material. The Medina sandstone is over 1,000 feet thick and has been excavated to form the southern side of the basin of lake Ontario. It contributed by preglacial decay and glacial erosion the material for the sand and the greater proportion of the gravel and cobble of all the water deposits of this region. The overlying Clinton shales and thin bedded limestones with shale partings, and the 80 feet of Niagara arenaceous shale supplied the bulk of the silts. The Niagara limestone occurs in the drift chiefly as boulders.

At the time of the formation of the Rochester moraine the Ontario glacier had probably become quite stagnant, and ablation of the surface had doubtless exposed the lower portion of the ice which was heavily charged with material from the Ontario excavation. The conditions thus favored the rapid accumulation of detritus, along certain portions of the ice front, by the heavy drainage from the rapidly dissolving ice.

It is also suggested that the Warren waters had removed the thin edge of the ice sheet so rapidly by melting and flotation that little opportunity was given for local accumulation of any kind of glacial material over a belt several miles wide south of Rochester. When the balance between the ice-flow and the ice destruction was established for a short time

at the line of the Rochester moraine, the conditions were peculiarly favorable for dropping the detrital ice-burden rapidly and in large amount. The areas immediately north and south of the Pinnacle hills are quite free from morainic accumulations, although covered by lake silts. The materials that under some conditions might have been scattered over a large area are here concentrated in a narrow belt. Three or four moderate streams at intervals of nearly one mile apart could have produced the Pinnacle hills in a comparatively short time. Perhaps such an interval was not too close for the drainage lines of this rapidly dissolving ice-front.

Comparison with Neighboring Kame Areas.

The Pinnacle hills are far from being the only kame-like deposits of the region, for over the relatively smooth plain of Monroe county several other accumulations of sand and gravel are conspicuous. At least two of these surpass the Pinnacle hills in amount of material. As these neighboring deposits have a bearing upon the subject under discussion they will be briefly described.

(1). *The Chili Sand Hills.*—Six miles southwest of Rochester occur some curious hills and knolls composed chiefly of fine sand. These knolls are partly indicated in the map. They are twenty to forty feet high, lying upon a foundation of till. Among themselves they have no order, but have individually an east and west elongation. They lie in a northeast by southwest belt about one mile wide chiefly between the New York Central railroad (main line) and the Chili wagon road and reach northeast to the moraine, which is there partly of the same character. Two drumlins lie in the eastern edge of the sand belt partly covered with the sand, and another may form the base of the larger group of sand knolls. The higher of the sand knolls have an altitude of over 620 feet. Upon the highest summits are numerous granitoid boulders, evidently ice-rafted. These hills have been studied by Mr. Frank Leverett. They appear to have been formed by the drainage from the glacier, with deposition in lake Warren. The east and west elongation may be regarded as indicating a morainic origin.

(2). *The Lincoln Park Kame Area.*—Close to the western border of the city and north of the moraine is another area of

sand and gravel forming part of the moraine. As indicated upon the map, the northernmost mound of the area is a distinct kame, over one-fourth of a mile long, lying in east and west direction, or parallel with the moraine, and consisting chiefly of fine gravel. It lies about one and one-half miles north of the moraine. Between this kame and the moraine and forming part of the latter are a series of low gravel and sand mounds, which make a connected series and grade in material from the gravel of the northern mound to fine sand at the moraine.

(3). *Red Creek Sand Knolls.*—Lying one to three miles south of the western end of the Rochester kame-moraine is a series of scattered low mounds of fine sand. The southeastern corner of Genesee Valley park forms part of this sand area which is there exposed by the Lehigh Valley and the Erie railroads. Other somewhat conspicuous mounds, ten to twenty feet high, occur along the road leading to West Henrietta, and the farthest lie across and below the West Shore railroad west of Red Creek Junction. The map shows only the northern part of this area.

(4). *The Brighton Sand Knolls.*—These are indicated upon the map, lying north and east of Brighton village, between the east end of the Pinnacle range and the Irondequoit excavation. These are a part of the eastward extension of the moraine, which from Brighton trends southeast, indicating the natural lobing of the ice-front in the deep excavation of the Irondequoit valley.

(5). *The Irondequoit Kame Area.*—Extending from the head of the deeper part of the Irondequoit valley up the shallower valley, or southward, for ten miles, is a kame series of great proportions. It represents the drainage deposits from the Irondequoit lobe of the Ontario glacier, and probably far exceeds in quantity the Pinnacle hills. The northernmost hill is just reached by the map. The series extends east of south from Allen Creek past Pittsford, ten miles, to Victor. It has been described in the article by Dr. Dryer referred to in the introduction of this paper.

(6). *The Mendon Hills Kame Area.*—The largest and most interesting of the kame-like sand and gravel deposits of the region are the Mendon hills in the southern part of Monroe

county, about ten miles from Rochester, east of south. Next to the "Turk's hill" mass of drumlinoid drift in the extreme southeast corner of the county, the Mendon sand hills are the highest land in the county, rising over 840 feet above sea level. These hills have an irregular grouping and cover an area of nearly four square miles. They can be roughly described as two series of very irregular kames having a general direction of S. 30° W., and with a valley between containing five ponds. These are the only ponds of note in the county. The intermediate valley is lower than the drumlinoid surface surrounding the two kame series. The northern pond is the largest and highest, having a surface 662 feet above tide. The sand hills, therefore, rise above the marshy valley quite two hundred feet. They are exceedingly varied in form, conical, mammillary, billowy, and enclose basins and kettles. The composition is also complex, being mainly fine gravel and sand but with some till. These hills seem to be isolated and to have no relation to any moraine or to any line of drainage. They are surrounded by heavy drift, distinctly drumlinoid in form, the ridges having a direction S. 20°–30° W.

SUMMARY.

The Pennock [illegible] of Rochester, N. Y., are regarded as part of a frontal moraine [illegible] for the following reasons:

1. The [illegible] curvature.

2. The [illegible] well-defined moraine [illegible]

3. The [illegible] intricate [illegible] bay of moraine [illegible]

4. The [illegible] knob and basin [illegible]

5. The [illegible] point of the range [illegible] line of the moraine.

6. The [illegible] and recurrent [illegible]

The [illegible] especially upon [illegible]

8. The [illegible] beds on the [illegible]

[illegible] waves of lake

Warren, which laved the front of the glacier, is believed for the following reasons:

1. The beds on the north side of the hills consist of coarse and poorly assorted materials.

2. The beds upon the south sides of the hills are mostly fine sand.

3. The coarse beds forming the north side of the hills have generally a decided east-of-south dip or inclination across the trend of the range.

4. The fine sands upon the south flank of the range are horizontally bedded and are undisturbed. They must have been deposited in comparatively quiet water, and directly upon *terra firma*.

5. The silt and sand, over 72 feet deep, constituting the middle ridge or heart of the South Goodman street section was deposited in a body of quiet water. The same is true of other sections, particularly in the large sand pit near Brighton.

6. In some exposures the fine oblique lamination of the sand beds indicates currents of the water southward, or east of south.

7. Over the low plain southward are fine surface silts and workable clays, representing the ultimate product of assorting and deposition by water.

8. Heavy boulders occur in the fine silts, especially southwest of Rochester, explainable only by flotation in ice.

EDITORIAL COMMENT.

The Feldspars.

As a mineralogical assemblage the feldspars have played a leading role in the laboratories of all mineralogists. They have been the basis of the most prolonged chemical research and of the most refined petrographic methods. They have been embraced differently in various classifications; the monoclinic and the triclinic, the orthoclastic and the plagioclastic, the acid and the basic, and the last again divided into acid and basic. The plagioclases have latterly been arranged, ac-

cording to views of Tschermak, in a series from albite to anorthite, called the soda-lime feldspars, in which albite and anorthite stand at the extremes, the former representing the largest percentage of soda and the latter the largest of lime. All the intermediate feldspars are, by this classification, considered variable and indeterminable mixtures of albite and anorthite. These would include oligoclase, andesine, labradorite and bytownite, but it excludes microcline which is also a triclinic feldspar nearly approaching orthoclase crystalligraphically, and identical with it, according to Michel-Lévy, only differing from it in having evident both albite and pericline twinning.

This theoretical chemical arrangement into a graduated series has become very popular as, after its adoption by Rosenbusch, it found its way into most German and English works on mineralogy, and is also generally taught in American schools of petrography. It is probable, however, that, while for its convenience it will serve as a useful grouping of a lot of facts unknown, it is still destined to be superseded in its ordinary interpretation by more exact knowledge. There is a certain plausibility also which is apparent in its main idea. Nothing is more common than a minute intercalation of two kinds of feldspars. Albite and orthoclase are characteristically thus closely intergrown, as in perthite. All twinning, even of the plagioclases, seems to be based on minute molecular variations which are, as yet, unascertainable, but which still probably have their chemical as well as their physical manifestations, and could be presumed to have resulted in such chemical variations as the law of Tschermak requires.

Notwithstanding the popular approval of what may be designated the German school of petrographers on this subject, the nice microscopic researches of Messrs. Fouqué, Michel-Lévy and La Croix, in calling attention to constant physical differences between the feldspars of this series have gone directly against the idea of their being made up by variable mixtures of chemical units, and have demonstrated the validity and the constancy of the various species. Microscopic research cannot be said to have yet reached the point where it traces the chemical atom from place to place and detects its

physical relations to surrounding atoms, but it is in the direction of this preciseness that these researches tend. The chemical method of distinguishing between these feldspars, which is the ultimate theoretical basis of the law of Tschermak, encounters the indefiniteness of chemical solutions, and the variations of chemical balances. It depends largely on the determination of chemical quantities when they are in unknown amounts and set free from their normal affinities. The exigences of evaporation, unequal heating at critical readings, loss by contact with the apparatus and with the reagents—these impose on all chemical determinations certain limitations which render it impossible in this way to enter into the minutest mineralogical distinctions, and which puts before the law of Tschermak *a priori* an obstacle which seems to render it fundamentally unsatisfactory to the human mind. Physical methods, however, have only to do with fixed quantities, with solids which manifest always the same physical characters, and if the refinement of the appliances be sufficiently nice, they are the best adapted for the examination of the differences that exist between the feldspars. A feldspar is a solid. On solution it is no longer a feldspar. On fusion it may contain the same chemical elements but it cannot be called a feldspar. A feldspar possesses definite external form and crystalline interior. Its proper examination should, therefore, be physical and its specification should be dependent on the characters that crystalline solids exhibit.

Now the physical examination of the plagioclases has been greatly advanced by the researches of Michel-Lévy. American students are hardly aware of the state of progress to which this art-science has been carried. Michel-Lévy has tabulated the properties of the plagioclases as derived from an examination of thin sections cut parallel to the bases of the crystals and also in those cut parallel to their brachypinacoids. While much of this was known before, the full classification and expression of the differences is due to the optical and mathematical skill of Michel-Lévy. These tables are to be seen in *Etude sur la determination des feldspaths dans les plaques mince au point de vue de la classification des roches*, published at Paris in 1894. These tables consist of circular plates representing the stereographic projection of the crystal and its

properties on a plane. Within these plates are expressed graphically the figures of maximum extinction and the directions of their variations from pole to pole, also the curves of double refraction, their relations to the different axes of elasticity and the differences which the plagioclases of the albite-anorthite series manifest. These tables are accompanied by a descriptive text and a full discussion of the methods.

M. Fouqué has recently added another chapter to the physical examination of the feldspars. It is a publication of the *Société Française de Mineralogie* (Tome XVII, Nos. 7 and 8, 1894) and differs from that of Lévy principally in the choice of different planes within the crystal, from which to draw optical properties. Whereas Lévy employed the sections parallel to the base and the brachypinacoid, Fouqué has cut the crystal in planes perpendicular to its bisectrices. He thus avoids some of the difficulties inherent in the observation of the maximum extinction on cleavages in the base and brachypinacoid, although he encounters others which are, perhaps, at present equally formidable to the ordinary student viz., the discovery of the plane of the optic axes and the cutting of the crystal perpendicular to the bisectrix. But the chief advantage of the method of Fouqué seems to lie in its avoidance of the actual observance of the maximum extinction of light. The eye is not sensible of small changes in the amount of light. There is need of making many readings and of taking the average of these to warrant the observer in affirming the angle of greatest extinction. In place of a difference in light, Fouqué substitutes a difference in form, which centers in the interference figure. When this figure is perfect it can easily be observed. When the hyperbolas are farthest removed from a cross in the field of the microscope the optic plane is at the angle of greatest extinction which can be read from the rim of the stage in the same manner as that obtained by maximum extinction of light.

There remain, of course, other directions in which crystals can be cut and examined, viz., those perpendicular to the optic axes, in which, as M. Fouqué remarks, there are numerous properties of the various feldspars yet to be worked out. When these, and other microscopic physical properties by which the feldspars are presumably marked, are discovered

and described, the masks which now obscure them and which make them appear similar will be removed, and each one will be recognized and easily distinguised from the rest.

At the present stage of this investigation M. Fouqué has felt warranted in referring to the law of Tschermak, calling attention to its crudity and to the frailty of its foundation.

After acknowledging the beauty and simplicity of the law of Tschermak, and its undeniable utility in many mineralogical determinations, he remarks that it encounters two objections of equal gravity. These may be given in a free translation from his late contribution:

First, then, if all the lime-soda feldspars result from a simple association of albite and anorthite, why is it that one of the parties to this association, albite, never shows itself individualized among the crystals of volcanic rocks, while the other, anorthite, is very frequently so seen, and in a state little short of actual purity. In the zoned individuals, composed of different triclinic feldspars, anorthite figures often as an element that is distinguishable with the microscope, albite never. Here, then, is a mineral which is found in very distinct individuals almost exclusively in stratified or metamorphic regions, which almost never appears in a crystalline determinable form in volcanic rocks, but which nevertheless, in consequence of its association with anorthite, should be of extreme frequence.

That which gives special force to this objection is the fact that, according to the theory of Tschermak, the complex feldspars are not definite chemical compounds, but simple mixtures of those two elements, viz., the albite and the anorthite molecules, framed in the same crystallographic mould. Each element, in whatever state of division it may be supposed to exist, enjoys its proper individuality. In order that it may enter into the supposed association it is necessary, in the first instance, to admit that its physical molecule has acquired its individual constitution and even that it already possesses a crystalline structure conformable to that of the mineral. In other words, the formation of a complex feldspar implies the crystallization of albite, if not before, at least concomitantly with the other elements and that, too, under conditions eminently unfavorable, and actually in a manner which is opposed by all that nature teaches of the formation of albite in regions that have been studied.

It is true that albite figures largely in the state of individualized crystals in the potash-soda series, but it is in veins of later date than the formation of the potash feldspar, and its formation can be assigned to its normal manner of production, in secondary genesis rather than to crystallization from fusion. And, as to the rocks which contain microlites of albite, recently discovered and studied by Michel-Lévy, it is in a pre-Tertiary rock much changed, and the albite may have been the result of such change.

The crystallization of this mineral from a fused mass is certainly not impossible. The tests of M. Hautefeuille sufficiently show that, but it is at least very difficult. The production of albite, therefore, is scarcely probable in these conditions, even when the generating magma possesses, either originally or after various liquations or crystallizations, a composition which is nearer that of albite than of anorthite.

But the objection just presented, although very strong, does not constitute, however, an argument which cannot be answered. It may be said, indeed, that the formation of a crystalline molecule of anorthite may exert a decisive influence upon the formation of a molecule of albite, and that that which is not possible in the absence of a basic element takes place easily in its presence, especially at the moment when its atoms are the seat of intense movement. In chemistry such cases are common. A body which refuses to crystallize when it is alone, for want of a solvent, often crystallizes readily under the action of a neighbor of similar constitution, or even, sometimes, of unlike constitution. In this case anorthite would play a role of this kind, and would be the element which would determine the crystallization of albite.

The objection, therefore, leads to controversy. Let it be set aside, and let the discussion be confined to the decisive fact which appears to demand an interpretation of the law of Tschermak different from that which is generally adopted.

This fact is the frequent observation of certain of the types of feldspar which are intermediate between albite and anorthite, and the rarity of certain others. The studies that I have set forth in previous portions of this work appear to me to leave not the least doubt on this fact, however inexplicable under the hypothesis of an association or physical mixture of albite and anorthite.

The serial discontinuity, indicated in the group of the lime-soda feldspars, is still more evident in the potash-soda feldspars, without speaking of certain anomalies peculiar to this last group. In order to account for this fact it appears to me necessary to admit that between albite and anorthite there exists a certain number of intermediate feldspars with a definite composition, forming by themselves a natural family, a series that may be compared to similar series so well established in organic chemistry. In the series to which I allude, the extreme terms being known, the properties of the intermediate compounds are exactly determined. It may be supposed that the same can occur in the inorganic world. Such a hypothesis, at least, offers nothing contrary to ordinary scientific principles.

If this is admitted it leads to the same practical conclusions as the theory of Tschermak. It furnishes the same facts as to the composition and as to the physical properties of the intermediate feldspars, and, further, it has the advantage of explaining a mineralogical peculiarity as to which the theory of Tschermak is silent.

The intermediate feldspars having a definite composition, here referred to, are susceptible of physical association and the formation of compound crystalline bodies, but it should be noted that this is not a

purely hypothetical mixture, such as constitutes the basis of Tschermak's theory. These associations are visible under the microscope, sometimes even to the naked eye. Chemical tests show them, as well as separation by heavy liquids, in all favorable conditions. It is a matter of real phenomena and not a conception of the imagination. The zoned crystals are exceedingly common, but a multitude of observations have shown their integral components.

The idea of these mineralogical types is not new. Mineralogists of the first half of our century made labradorite, oligoclase and andesine distinct species. Later M. Des Cloiseaux recognized in the oligoclase group separate types with well-marked characters.

How does it happen that, instead of trying to separate and define these types and to establish their individuality, modern science has preferred, on the contrary, to make them disappear, and even to deny their actuality? * * * * * *

Mr. Fouqué concludes as follows:

1. There are feldspathic types, of definite composition, intermediate between albite and anorthite.

2. These feldspars are capable of uniting together in physical association.

3. Several of them are visible generally in the same rock, sometimes in large crystals and sometimes in the form of microlites, but nearly always with the preponderance of one of them at each consolidation.

4. Most frequently the order of acidity is in inverse order of their formation, and the glassy material which constitutes the residue after crystallization is more siliceous than the most acid of the feldspars.

These aphorisms, which were announced by me some years ago, after the study of rocks upon a limited district and with limited means of investigation, are to-day supported by the results of study over a large field, and with the aid of the perfect methods introduced during the last fifteen years of the science.

The last contribution to this research is by Michel-Lévy, in a communication read before the *Societe Française de Mineralogie.** It is based on the spherical projections and figures of extinction which he had before deduced for the plagioclases (*Etudes sur la determination des feldspaths*). By means of these he constructs a general plan showing the spherical projections of simultaneous extinctions of the parts of compound mineral bodies, like the plagioclases, and their relations to the spherical traces of the optic axes of the compound mineral. Each of the points of these curves where the ellipses of the components have their axes crossed corresponds

*Recherche des axes optiques dans un mineral pouvant être considéré comme un mélange de deux minéraux déterminés. Application aux plagioclases et à la verification de la loi de Tschermak. 14 March, 1895.

to an optic axis of the compound mineral. Assuming that the law of Tschermak is true, it is found that the general principle deduced holds true in its application to the special cases between andesine and anorthite. Between albite and andesine it is not possible to say as much. It appears that in the vicinity of oligoclase something produces such deviations that no conclusions can be drawn. So far as it goes this shows a substantial confirmation, by the methods of optics, of the formulæ deduced theoretically for the composition of some of the plagioclases, but it is dependent on the assumption that the feldspars considered are of definite composition, and represent ascertainable and fixed conditions in their physical structure.

The studies of both Fouqué and Michel-Lévy tend, not so much to the denial of the law of Tschermak, as to its definition, and to the correction of the popular interpretation of it. At the same time they tend to establish definite characters, at least physical characters, for several new intermediate feldspars, and thus to eliminate the prevalent idea of vagueness and uncertainty which the law of Tschermak has propagated respecting those before known. If their chemical characters could be established with equal refinement there is great probability that the two methods would corroborate each other, but the mechanical separation of two or more of them when they are closely intergrown, which is almost always their natural condition, so that reliable chemical examination can be made, is as yet a very difficult and almost impossible task. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Om Didymograptus, Tetragraptus och Phyllograptus. Af GERHARD HOLM. (Geol. Fören. i Stockholm Förhandl., Bd. 17, Häfte 3, Sid. 319-359, Tafl. 11-16, 1895.) Dr. Holm has continued his studies on graptolites preserved in limestone, which he began a decade ago, in describing the intimate structure of a *Climacograptus* and a *Retiolites*. The chitinous parts of these organisms were freed by means of acid and their special structure clearly revealed.

In the three genera first above named he finds thecæ to have been formed earlier than has been supposed. The distal part of what has been considered the sicula is the first theca. Succeeding this he distinguishes two, following each other, the *sinistral* and the *dextral theca;* these, with the one on the sicula, comprise the *primordial thecæ*, which form the foundation of the polyparies of these genera. He discards the term funacle as unnecessary, there being no barren part to the polypary. He states also that he has not discovered a vergula in the *Dichograptidæ*.

The essay contains notes on the genus *Didymograptus*, with special reference to *D. gibberulus* Nich. The proximal part of *Tetragraptus bigsbyi* Nich., and *Phyllograptus angustifolius* Hall, are also fully described in this article. The article is illustrated with six well finished plates and several wood-cuts, and is an important one for students of the Rabdopora. G. F. M.

De l'existence de nombreux débris de Spongiaires dans le Précambrien de Bretagne. Par L. CAYEUX. (Ex. de la Société du Nord, T. XXIII, p. 52, 3 Avril, 1895.) The author illustrates this contribution to this ancient fauna with two plates. On these plates are figures of forms referred to Monaxes, Tetractinellidæ, Lithistidæ and Hexactinellidæ. These remains are found in the same rocks as the Foraminifera and Radiolaria already announced by M. Cayeux and noted in recent pages of the GEOLOGIST. The evidence of the fossiliferous nature of these rocks seems to be abundantly satisfactory. The only remaining doubtful element in the discussion is that of the age of the rocks themselves, on which there is not yet sufficient knowledge. In M. Cayeux's other paper he stated that his impression was that these rocks belong in the American "Algonkian," but that is to take them not only from the Cambrian but also from the Archean, and to put them into an uncertain limbo in which are found all unstudied rocks at about that horizon, and in which the sponsors for that term have included some rocks certainly Cambrian and others that may be Cambrian, as well as some that are probably Archean. In other words, in the absence of a known lower limit for Cambrian, and in the presence of similar organisms reported in several places in America from the Taconic (Lower Cambrian), taken with the author's idea that they are of "Algonkian" age, there remains much reason to hesitate to accept these fossil forms as Archean, or even as "pre-Cambrian." The nature of the rocks themselves, a *siliceous slate* intercallated with *an enormous formation of black slates*, which occupy a wide extent of territory in that part of Bretagne, presents an anomalous petrographic assemblage to be placed in the Archean. N. H. W.

Tertiary Rhynchophorous Coleoptera of the United States. By SAMUEL HUBBARD SCUDDER. (Monograph XXI, U. S. Geol. Survey, 1893. Pages xi, 206; with 12 plates. Price, 90 cents.) Four localities in Colorado and Wyoming have supplied 191 species of beaked beetles which are described in this work, 116 being from Florissant, all distinct from any found in the other places, and 75 from the Roan mountains and the White and Green rivers. A considerable number of species occur in

two or in all three of the last named localities, and their fossil insects are grouped together and named the Gosiute fauna. Both the Florissant and Gosiute beds have been regarded as Oligocene: but their unlike faunas show that they differ somewhat in age, although it cannot yet be decided which is the older.

From the European Tertiary strata only 141 species of this group have been discovered. Nine others are known in the European Pleistocene, while our continent has thus far only one Pleistocene species, this being from the interglacial beds of Scarboro, Ontario. Another species is discovered by Mr. J. B. Tyrrell in the Cretaceous Fort Pierre shales on the Assiniboine river, making a total of 193 known fossil American Rhynchophora. These all are specifically distinct from any found fossil in Europe, and from all known living species.

Notwithstanding the universal change in species from the Tertiary to the present time, the author affirms that "there has been but little important change in the insect fauna of the world since the beginning of the Tertiary epoch. In the earlier Tertiaries we not only possess in profusion representatives of every one of the orders of insects, but every dominating family type which exists to-day has been recognized in the rocks; even many of the families which have now but a meager representation have also been discovered, and though many extinct genera have been recognized, no higher groups, with a single exception or two, have been founded upon extinct forms." W. U.

A Manual of Topographic Methods. By HENRY GANNETT, Chief Topographer. Monograph XXII, U. S. Geol. Survey, 1893. Pages xiv, 300; with 36 mathematical tables, 18 plates, and 14 figures in the text. Price, $1.00.) The first 130 pages contain a description of the topographic work, instruments and methods used by the U. S. Geological Survey in its task of preparing a topographic map of the United States. The first chapter very concisely notices the several government and state surveys by which portions of the country have been previously mapped, and the general plan of the present work. The second chapter treats of astronomic determinations of position: the third, of the primary triangulation; the fourth, of the secondary triangulation, traverse work, barometric determination of hights, etc.: the fifth, of the field sketching, with a detailed review of the geologic agencies giving origin to topographical features, as uplifts, volcanism, sedimentation, stream, wave and subaërial erosion, glacial deposition and erosion, and wind action; and the sixth and final chapter relates to the office work of drafting. Streams, lakes, marshes, and the sea, are drafted and printed in blue; the culture delineations and lettering are in black; and the contours in brown (burnt sienna).

The second half of the volume is a series of tables used in the reduction of astronomic observations for position, of triangulation, of hight measurements, and other operations connected with the making of topographic maps. This work was primarily intended for the information of the men engaged on the national survey; but it has been found

also very serviceable by other surveyors and engineers and by teachers in technical schools. W. U.

Reconnoissance map of the United States, showing the distribution of the Geologic Systems, so far as known. Compiled from data in the possession of the U. S. Geological Survey, by W J McGEE, 1893. This set of twelve maps, which are classed together as plate II of the forthcoming Fourteenth Annual Report of this survey (for 1892-'93), is issued in advance of that report. The scale is about 110 miles to an inch, being the same with that of the geologic map compiled by Prof. C. H. Hitchcock about ten years ago. Professor Hitchcock's map has geologic coloring extended provisionally over the entire United States, and across the border of Canada to the limit of the sheet; but the present map omits coloring from Canada, and from areas where the exact boundaries of the formations have not yet been traced. Thus a large region of western Montana, Idaho, Oregon, and southern Washington, comprising the great volcanic area crossed by the Snake and Columbia rivers, remain uncolored on Mr. McGee's map.

Another and more regrettable departure from the earlier map is the omission of the Cretaceous color from a large tract of eastern North and South Dakota, giving to it only the designation of glacial drift. This tract was rightly called Cretaceous by Hitchcock; and the same Cretaceous formations, according to Prof. N. H. Winchell in the frontispiece map of the Geology of Minnesota, Vol. III, Part I, also continue eastward, beneath the drift, upon the western half of that state. In this opinion the present reviewer confidently accords, and would also include the northwestern quarter of Iowa in the eastern extension of the Cretaceous area.

Besides the comprehensive geologic map, with its contour lines, this series comprises an uncolored map with only contours, and ten other maps showing respectively the areas of (1) the Pleistocene ice and water deposits, these alone being colored; (2) Neocene and Eocene formations; (3) the Cretaceous; (4) the Jura-Trias; (5) the Carboniferous; (6) the Devonian; (7) the Silurian; (8) the Cambrian; (9) the Algonkian and Archean; and (10) igneous rocks. The Pleistocene formations are displayed by overprinted dots. The scheme of colors is very tasteful, with mostly lighter tints than on Prof. Hitchcock's map.

A further improvement, very helpful for convenient reference and study, is the more frequent insertion of names of cities, towns, rivers, lakes, bays, capes, etc. Among these the name of lake Itasca is wrongly spelled, with *k;* its derivation being from the Latin words *veritas* and *caput*, by Procrustean elision of the initial and final syllables. W. U.

Interlocutial Till near Sioux City, Iowa. By J. E. TODD and H. FOSTER BAIN. (Proceedings of the Iowa Academy of Sciences, vol. II, 1895 pp. 20-23.) At the hight of about 150 feet above the Big Sioux and Missouri rivers, a deposit of typical boulder-clay or till, having an observed maximum thickness of six feet, is underlain and overlain by ordinary loess.

The intercalated till is many feet above any other known glacial drift in the vicinity. It is referred to deposition from a mass of floating ice laden with débris from the adjacent ice-sheet. The origin of the drift generally in the surrounding region to the south of the Altamont or outermost moraine, which lies at a distance of 20 to 30 miles north of Sioux City, is supposed by the authors to have been likewise from floating bergs and floes. The extramorainic till there "is thin and patchy, being usually not over fifteen feet in thickness. That the region has not been covered by the heavy land ice would seem to be indicated, not only by this, but also by the general presence of beds of fine sand and clay under the drift, and showing no signs of disturbance." W. U.

Preglacial Elevation of Iowa. By By H. FOSTER BAIN. (Proc. Iowa Acad. of Sciences, vol. II, pp. 23-26.) Numerous deep, drift-filled valleys, cut 100 to 300 feet below the general surface of the bed-rocks, are described as found by well borings throughout Iowa, and their erosion is good evidence of a long preglacial period of considerable elevation. It remains undetermined, however, whether this valley erosion took place chiefly during the great Tertiary cycle of base leveling, or during the less prolonged early Pleistocene period of renewed uplifting and stream channeling which immediately preceded the Ice age. W. U.

A Bibliography of North American Paleontology, 1888-1892. By CHARLES ROLLIN KEYES. (U. S. Geological Survey, Bull. No. 121, 251 pp., 1894.) This work embraces: (1) An author's list, in which is given the full title, volume, etc. Each title is followed by a brief synopsis of the paper, an enumeration of the new genera and species described, and a list of forms already known, which are described and figured anew. (2) A title index. (3) Subject entries and cross references. Under the last head each article is included under its appropriate biological, geological and geographical divisions.

The present bibliography is thus seen to be much more complete than most works of a similar nature. In addition to being an index and catalogue, it is really a condensed review of all literature pertaining to paleontology published during the period from 1888 to 1892. It is thus of great aid to those who do not have access to a complete library. The amount of work required to produce such a bibliography as the above must have been very considerable, but its usefulness to the paleontologist and to the general geologist will fully compensate for the labor bestowed upon it. U. S. G.

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III. Papers in Scientific Journals.

Science, May 24, 1895. Current notes on physiography (VII), W. M. Davis.

Science, May 31, 1895. Current notes on physiography (VIII), W. M. Davis.

Amer. Jour. Sci., June, 1895. Crystal form of borneol and isoborneol, W. H. Hobbs; Synopsis of the mode of growth and development of the graptolitic genus Diplograptus, R. Ruedemann; Newly discovered dike at DeWitt, near Syracuse, N. Y., N. H. Darton and J. F. Kemp; Note on the amount of elevation which has taken place along the Rocky Mountain range in British America since the close of the Cretaceous period, G. M. Dawson; Three new analyses of sodalite from three new localities, L. McI. Luquer and G. J. Volckening.

School of Mines Quarterly, April, 1895. Contributions from the mineralogical department of Columbia College, XXI, A. J. Moses; Monazite and orthoclase from South Lyme, Conn., W. D. Matthew.

Ottawa Naturalist, June, 1895. Notes on the stratigraphy of the Cambro-Silurian rocks of eastern Manitoba, D. B. Dowling.

Am. Naturalist, June, 1895. Is Dæmonelix a burrow? A reply to Dr. Theodor Fuchs, E. H. Barbour; Sponges, recent and fossil, J. F. James

IV. Excerpts and Individual Publications.

Notes on some eruptive rocks from Gallatin, Jefferson and Madison counties, Montana, G. P. Merrill. Proc. U. S. Nat. Museum, vol. 17, pp. 637-673, (No. 1031), 1895.

The rocks of the Sierra Nevada, H. W. Turner. 14th Ann. Rept. U. S. G. S., pp. 435-495, pls. 48-59, 1895.

Tennessee phosphate rocks, J. M. Safford. Reprint from Rept. Com. of Agriculture. 16 pp., 1895.

On the structure of the ridge between the Taconic and Green Mountain ranges in Vermont, T. Nelson Dale. 14th Ann. Rept. U. S. G. S., pp. 525-549, pls. 66-70, 1895.

On the structure of Monument mountain, Great Barrington, Massachusetts, T. Nelson Dale. 14th Ann. Rept. U. S. G. S., pp. 551-565, pls. 71-72, 1895.

The laccolitic mountain groups of Colorado, Utah and Arizona, Whitman Cross. 14th Ann. Rept. U. S. G. S., pp. 157-241, pls. 7-16. 1895.

Geological section—St. Louis to Shawneetown, J. M. Nickles. Final Report of the Illinois Board of World's Fair Commission, pp. 155-223, 1 pl., Springfield, 1895.

V. Proceedings of Scientific Laboratories, etc.

Univ. of Cal., Bull. Dept. Geol., vol. 1, no. 10. On lawsonite, a new rock-forming mineral from the Tiburon peninsula, Marin Co., Cal., F. L. Ransome. Pp. 301-312, pl. 17, May, 1895.

CORRESPONDENCE.

INTERGLACIAL CLIMATIC CONDITIONS. In the article by Mr. Warren Upham, printed in the May number of the AMERICAN GEOLOGIST and entitled "Climatic Conditions shown by North American Interglacial Deposits," it appears to me that the author very greatly underrates the evidences of a warm climate afforded by the plant remains found in the deposits of this age in the vicinity of Toronto. The particular beds in which these remains have been found at Toronto and Scarborough may for the present be assumed to be contemporaneous, for, although this has not been absolutely proved, the evidence they give is at least concurrent.

In these beds the following species of plants have been recognized: (1) *Asimina triloba*, (2) *Fraxinus quadrangulata*, (3) *Quercus obtusiloba*, (4) *Ulmus racemosa*, (5) *Taxus baccata* var. *canadensis*, (6) *Acer pleistocenicum*. Of these the yew (No. 5) is too wide spread in habitat to give much information, and the maple (No. 6) is supposed to be a species now extinct, but the four first-mentioned plants are all, for the region, southern forms, which here reach or surpass their present northern limits. This statement may be verified by consulting Prof. Sargent's "Forest Trees of North America" and Prof. Macoun's "Catalogue of Canadian Plants." Prof. Macoun, in fact, records the two first-named species in Canada *only* from the shore of lake Erie; the third he recognizes doubtfully in the southern part of Ontario, while the fourth is not quite so distinctively southern in habitat, being found sparsely both in southern Ontario and in the "Eastern Townships" of the province of Quebec.

To assume, as Mr. Upham* does, that these trees flourished when "the ice-sheet was melted away from the region of the Upper Laurentian lakes as far eastward as Toronto, while yet it remained on the

*Loc. cit., p. 290.

northeastern part of the basin of lake Ontario, on northern New York, and the greater part of New England," and that "the ice border during that whole time was near," seems to me to be wholly opposed to the evidence in our possession. It is surely evident that the mere proximity of such continental ice surfaces would have resulted in the occurrence of killing frosts nearly every clear night during the summer, and that no conditions less favorable, or less remote from such arctic influences than those now found in the same region, are at all compatible with the facts.

I am not aware that any of the plants found about the edge of the Malaspina glacier in Alaska* attain their highest northern range for the continent there, but even if this were the case, the climatic conditions to be reckoned with on the Pacific coast are quite different from any which could possibly have occurred during the Glacial period in the eastern part of America. GEORGE M. DAWSON.

May 20, 1895.

PERSONAL AND SCIENTIFIC NEWS.

DR. EDWARD B. MATHEWS, instructor in mineralogy in the Johns Hopkins University, is spending the summer in study in Germany.

MR. HARRY A. LEE has been appointed Commissioner of Mines of Colorado by Gov. McIntire. A bill was recently passed establishing a state bureau of mines in Colorado similar to that in California. (*Eng. and Mining Journal.*)

HON. ECKLEY B. COXE, of Drifton, Pa., died on May 13th. Mr. Coxe was a well known mining engineer and was one of the organizers and early vice-presidents and presidents of the American Institute of Mining Engineers.

MR. J. S. DILLER, of the U. S. Geological Survey, passed through Minneapolis on June 8th. He was on his way to investigate the Tertiary coal beds a short distance west of Portland, Oregon.

PROF. KARL A. VON ZITTEL'S paper on "Palæontology and the Biogenetic Law," which was read before the International Congress of Geologists last summer, has recently been published in *Natural Science* (No. 39, May, 1895).

DR. HENRY WOODWARD, president of the Geological Society of London, at the last meeting of that society chose for the subject of his presidential address, "Some points in the life-history of the Crustacea in early Palæozoic times."

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will meet at Ipswich from Sept. 11th to 19th. The president is Sir Douglas Galton. Mr. W. Whitaker, of the Geological Survey of Great Britain, is president of section C (Geology).

*Ibid., p. 288.

DR. KARL VOGT, for many years professor of geology at Geneva, died on May 6th, at the age of 78 years. He was born at Giessen and studied under Liebig and Agassiz. Before his appointment at Geneva he had held a similar chair at the university of his native town.

MR. BAILEY WILLIS, of the U. S. Geological Survey, and assistants will make a reconnaissance of the mineral resources in the vicinity of Puget sound. This region is already somewhat familiar to Mr. Willis from his work on the Northern Transcontinental Survey.

THE UNIVERSITY OF CHICAGO has lately distributed the programme of the department of geology, 1895-1896. Brief accounts of the aims of the department, the equipment, library facilities and courses of instruction are given. The officers of instruction number eight, and there are thirty-one courses offered.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting on May 22d the following papers were read: Questions in regard to the former extent of continental areas suggested by the distribution of oceanic fishes, by G. Brown Goode; The North American continent in Cretaceous and Tertiary time, by G. K. Gilbert; Recent examination of the Cambrian in Georgia and Alabama, by C. D. Walcott.

THE GEOLOGICAL SOCIETY OF AMERICA will hold its seventh summer meeting Tuesday and Wednesday, August 27th and 28th, in the Art Museum, Springfield, Mass. Several excursions to points of geological interest in the neighborhood of Springfield have been arranged. These will be conducted by Profs. W. O. Crosby, W. M. Davis, W. N. Rice and Wm. H. Hobbs.

THE SIXTH INTERNATIONAL GEOGRAPHICAL CONGRESS, which meets in London from July 26th to August 3d, has made arrangements for an exhibition. It has been definitely arranged that the exhibition, as well as the Congress, will be held in the building of the Imperial Institute, South Kensington. The exhibition will be opened early in July and will probably remain open until the middle of September.

THE GEOLOGICAL SOCIETY OF LONDON has adopted the plan of issuing in a separate pamphlet the catalogue of literature, mainly of course geological, which was added to its library during the last six months of 1894. It is double, the first part under the author's names and the second under subject-titles. It fills 58 closely printed pages. It will prove, if continued, as we hope it will be, a very valuable summary of geological literature.

MESSRS. G. F. BECKER and CHESTER W. PURINGTON, with DR. W. F. DALL, left Washington May 14th for a reconnaissance

of the mineral resources of Alaska, Congress having made a special appropriation of $5,000 for that purpose. The work of the season will be confined to the coast, and an examination of the upper Yukon will not be attempted.

THE COLORADO SCIENTIFIC SOCIETY has recently issued the fourth volume of its "Proceedings." This volume contains xxix and 456 pages and includes the proceedings and papers for 1891, 1892 and 1893. Some of the more important papers were reviewed in the AMERICAN GEOLOGIST at the time of their appearance in separate form. The contents of this volume are given under the head of "Recent Publications" in this issue.

THE ROYAL SOCIETY OF CANADA held its fourteenth meeting at Ottawa, May 15th, 16th and 17th. The following geological papers were read: The geology of the proposed Ottawa ship canal, by R. W. Ells; Note on Tertiary fossil plants from the vicinity of the city of Vancouver, B. C., by Sir William Dawson: Organic remains of the Little River group, No. 4, by G. F. Matthew; The chemical composition of andradite from two localities in Ontario, B. J. Harrington.

BULLETINS OF AMERICAN PALEONTOLOGY. This is a title of a new serial issued under the direction of Gilbert D. Harris, Ithaca, N. Y. It is intended that these bulletins will appear when suitable material is prepared for them and not necessarily at regular intervals. They will not represent work done merely by one person or institution, but will be of a more general nature—subject to acceptable contributions from all paleontological workers. No. 1 is entitled "Claiborne Fossils," part I, Synonymy of Lea's and Conrad's species; part II, New or remarkable species.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its forty-fourth meeting at Springfield, Mass., Wednesday, Aug. 28th, to Saturday, Sept. 7th. Information relating to membership and papers can be obtained from the permanent secretary, Prof. F. W. Putnam, Salem, Mass., while the local secretary, Mr. W. A. Webster, of Springfield, will attend to all inquiries concerning arrangements, hotels, railway rates, etc. A number of general and special excursions have been arranged for the members of the Association and other societies. The following societies will meet at Springfield in connection with the A. A. A. S.: Geological Society of America; Society for the Promotion of Agricultural Science; Association of Economic Entomologists; Association of State Weather Service; Society for Promoting Engineering Education; American Chemical Society; American Forestry Association.

ST, 1895. VOL. XVI, No. 2

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THE AMERICAN GEOLOGIST,
Vol. XVI, Plate IV.

THE

AMERICAN GEOLOGIST.

VOL. XVI. AUGUST, 1895. No. 2.

JOSEPH GRANVILLE NORWOOD, M. D., LL. D.

By G. C. BROADHEAD, University of Missouri, Columbia, Mo.

(Portrait, Plate IV.)

John Norwood, an English gentleman, was born in London and came to Virginia about 1740. He was an accomplished mathematician and left to his eldest son two manuscript works on mathematics.*

Charles, the eldest son of John Norwood, was born in 1753, and was a Revolutionary soldier. He was twice married, the first time, in 1781, to Anna Dale. After her death he moved to Kentucky, settling in Woodford county, and within a few years married Mildred Dale, a sister of his first wife. She was the mother of Joseph G. Norwood. During the second war with Great Britain Charles Norwood operated a powder mill, which he sold soon after the war closed and settled on a small farm near Lexington, where he died in 1832.

Joseph Granville Norwood was born in Woodford county, Kentucky, December 20, 1807. When six years of age he attended a school taught by a Scotchman named Buchanan. When nine years old he entered the school of Aldrich and Vaughan, taught on the Lancastrian system. The school contained nearly four hundred pupils, whose studies ranged from the lowest primary to higher mathematics. He remained in this school for about five years, officiating as head monitor during the last two years. Young Norwood's father moved

*One of these books was shown to me by the late Dr. Norwood and is now in the possession of the Norwood family.

into town and occupied a house near a printing office. The son, often observing the process of printing, became ardently desirous of becoming a printer. But his father earnestly desired him to study medicine. About this time he secured employment as clerk in the banking house of Mr. Winn. While thus engaged a Mr. Snell visited Lexington giving illustrated popular science lectures. Mr. Winn being an old acquaintance, Mr. Snell called to see him. Mr. Winn being absent, Mr. Snell presented the clerk with a ticket to the exhibition. The exhibition chiefly consisted of illustrations in chemistry and electricity. Heretofore young Norwood's evenings had been dull, but they were no longer so. A love for experimental science was then born in him. With the assistance of a tinner and with lenses obtained from a watchmaker he constructed a magic lantern. He prepared his own slides, using ivory black for outlines, a few transparent colors and colorless varnish. With bottles, a pane of glass, tin-foil, a stick of sealing wax, a skein of silk and elder pith a few electrical experiments were made.

He next entered a printing office, and afterwards purchased a newspaper and continued in that business for several years. The greater part of 1827 was spent in travelling. In 1828 he published a journal of medicine and in 1829 the "Christian Examiner." In 1830 Norwood and Palmer were engaged in printing and publication in Louisville, Kentucky. Norwood soon after sold out and determined to devote himself to the study of medicine and the sciences. He already had begun to devote all of his leisure to the study of scientific books. In the meantime he took control of the "Lexington Intelligencer" for a year, but finding that this interfered with his medical studies he soon withdrew and pursued his study of medicine at Transylvania Medical College. Toward the close of the second session of his medical course, although he was informed that he could secure a diploma, he determined to wait another year as he was not altogether satisfied with his acquirements. Without solicitation the entire faculty gave him recommendations and he at once entered upon the practice of medicine, and by the end of the year he was possessed of a large practice. The next year (1836) he returned to Lexington, wrote out a thesis on spinal diseases, and in March he graduated.

In 1840 the Indiana legislature chartered the Madison Medical Institute and Dr. Norwood was given the chair of surgery. In 1843 he was invited to a chair in the medical department of the St. Louis University. This position he held until 1847 when he was urged to enter upon the United States Geological Survey. From 1847 to 1851 he was assistant geologist with Dr. D. D. Owen on the survey of Wisconsin, Iowa and Minnesota, his work chiefly being near lake Superior. In 1854 he was elected to the chair of chemistry in the Kentucky Medical school at Louisville, but did not serve.

From 1851 to 1858 Dr. Norwood was state geologist of Illinois. From1858 to 1860 he was assistant geologist of Missouri. In 1871 Dr. Norwood was offered the position of state geologist of Missouri. He would only agree to accept the office until a state geologist was appointed. He held the office for three or four months.

From 1860 to 1880 he was professor in the University of the State of Missouri, filling the chairs of geology and chemistry, also of natural science, including physics, anatomy and physiology, and for several years he was dean of the medical department of the university. On account of ill health his active work with the university ceased in 1880. Since then his name has remained on the catalogue as emeritus professor of physics. Part of the time between 1861 and 1865 the regular university exercises were suspended and the university building was occupied by United States troops, but Dr. Norwood came regularly to the building and remained all day, faithfully watching over the university property.

About fifteen years ago Dr. Norwood met with a serious fall, which injured his hip and made it difficult to get about. For over twelve months previous to his death he suffered painfully at times from gravel, and during the last two months of his life the end of all seemed to be near. For months he took but little nourishment and during his last days it was mechanically given him. He died in Columbia, Missouri, May 6, 1895.

He was devoted to his family, faithful to his friends, fearless in his views and yet was never known to speak unjustly of any one. His mind was strong, it was clear and bright to the last. He possessed a gentle grace and a grand dignity

that made all who knew him love, honor and respect him. His scholarship was broad; he was accomplished in natural science and a thorough instructor, and universally loved by his pupils.

Dr. Norwood was twice married, his first wife being Miss Louisa Taylor. By this marriage he had two sons and one daughter. The daughter married Col. J. A. Hendricks, of Indiana, who was killed at the battle of Pea Ridge. Dr. Norwood's second wife was Mary Francis Pugh, of Madison, Indiana. Three sons and five daughters were born of this marriage. One of these daughters married John D. Vincil, D. D., of St. Louis, who is one of the most prominent free masons of the country. Charles J. Norwood, a son by Dr. Norwood's second marriage, has been state mine inspector of Kentucky for ten years, and is now state geologist of Kentucky.

Dr. Norwood was a mason for 67 years and was buried with masonic honors, and his remains were also escorted to the grave by the cadets of the University of Missouri. The council of the university, at a meeting held for the purpose, adopted resolutions extolling his many virtues and his great learning, stating that in his death the school, the State and education lost one whose place it would be hard to fill.

A prominent characteristic of Dr. Norwood was his extreme modesty as it concerned himself. All of the various positions that he has held were offered him without his seeking. I had been most intimate with him for thirty-five years yet I never found him praising himself, yet for his every action there was praise due to him. For the past three years I had endeavored to obtain certain information necessary to a sketch of his life, but he always evaded the subject and asked me to wait, and my respect for him was such that I could not urge the matter. He was a valued friend, a good man, a pure man.

Dr. J. G. Norwood's publications, so far as now known by me, were as follows:

1838. "Outlines of a Course of Lectures on the Institutes of Medicine." Lexington, Ky.

1841. "Family Medical Library." Published by U. P. James, Cincinnati. This was a revision, with additions, of Dr. Buchan's then well known English work.

1846. "Description of a New Fossil Fish from the Palæozoic Rocks of Indiana," by Joseph G. Norwood, M. D., and David Dale Owen, M.

D. February 16, 1846.—American Journal of Science and Arts, 2d series, vol. I, page 367. This was the *Macropetalichthys rapheidolabis*, and the description was the second notice of fish remains in the Cornif-erous. The genus was erected by Norwood and Owen.*

1846. "Description of a Remarkable Fossil Echinoderm from the Limestone Formation of St. Louis, Mo., by J. G. Norwood, M. D., and D. D. Owen, M. D. June 20, 1846.—American Journal of Science and Arts, 2d series, vol. II, p. 225. This was the *Melonites multipora*. The genus was erected by Norwood and Owen.

1847. "Researches Among the Protozoic and Carboniferous Rocks of Central Kentucky, made during the Summer of 1846," by D. D. Owen, M. D. and J. G. Norwood, M. D. St. Louis, 1847. This was an "excursion through part of Tennessee and Kentucky, by way of Nashville, Gallatin, Scottsville, Glasgow, New Haven and Bardstown," and was undertaken "with a view to clear up some doubtful points in western geology." The authors say: "The points to which our attention was mainly directed were to determine whether the 'Cliff' formation of the west—the Upper Silurian and part of the Devonian rocks of Europe—existed in Tennessee and the southern part of Kentucky; to observe the succession, bearings and relative area occupied by the protozoic and carboniferous or mountain limestone; and to collect, if possible, a greater variety of fossils from the strata above the black slate, which occupy the knobby region of the Western States, in order to obtain additional evidence of the true age of these deposits, which have been usually regarded, on lithological grounds, as having been deposited contemporaneously with the Portage and Chemung groups of New York and the Devonian rocks of Europe." They identified the "Cliff" formation in various places and decided that the deposits in question above the black slate "belong to the Carboniferous [also referred to as 'sub-carboniferous'] and not to the Devonian age." These "sub-carboniferous" beds are now known in Kentucky as the Keokuk-Waverly series, in part. The pamphlet is an interesting one on several accounts. It contains one plate of fossils and a horizontal section of the beds along the line of observation.

1848. First Report as Assistant U. S. Geologist in the Survey of the Northwest.

1852. Second Report as Assistant U. S. Geologist in the Survey of the Northwest.

Geological Report of a Survey of a portion of Wisconsin and Minnesota made during 1847, 1848, 1849 and 1850. 260 pages, large quarto, illustrated. Prof. N. H. Winchell, state geologist of Minnesota, has remarked upon the the thorough accuracy of this work of Dr. Norwood's.†

*NOTE.—A portion of the specimen described and figured is now in the collection of Missouri University, Columbia. Comparing this with description of *M. sullivantii*, Ohio Rep., vol. I, Pal., I am convinced that it is the same species, and Norwood's specimen has priority.

†Dr. A. Litton, of St. Louis, I believe is the only person now remaining who was engaged in that survey.

1851-1857. State Geologist of Illinois. Following the election of a Republican Governor, he (being a pronounced Democrat) was removed from office and the legislature refused to appropriate means to publish his report. Concerning the latter, a legislative committee reported as follows: "We refer the accompanying report of Dr. Norwood to his excellency, the Governor, and also the report of the topographer annexed to the same. From these reports it will be seen, first, that Dr. Norwood has materials of an entirely economic character, nearly ready for publication, which will make a volume of from one thousand to twelve hundred pages, with all the sections and diagrams necessary to illustrate the work," etc., etc. The committee also reported: "Your committee will further state that, in their opinion, there has not only been a large amount of labor performed at comparatively a small expense, but that it has been well done. No just cause of complaint can be urged against the present incumbent, Dr. Norwood, or any of his assistants." These brief extracts from the legislature's records may give to those whose knowledge of Dr. Norwood's services in Illinois is limited to, what his friends deem, a singular note in the first report of his successor, a different notion as to what the facts really were.*

During his term as state geologist of Illinois he made two reports of progress, one dated Feb. 5, 1853, and one Feb. 7, 1855; and in February, 1857, he was prepared to publish the report "of 1,000 or 1,200 pages" mentioned above, for which no appropriation could be obtained. Subsequently, however, in August, 1857, he published an "Abstract of a Report on Illinois Coals," 93 pages, with map and two plates of sections, the expense of which was met from a fund controlled by the Governor. This, with a short account of the Rosiclare lead region given in Vol. I of Worthen's reports (1866), contains, unfortunately, all the published results of his work in Illinois. It may be proper to state that Governor Bissell did not desire to remove Dr. Norwood, but was forced to yield to political pressure. Mr. Worthen's appointment was then made upon Dr. Norwood's urgent request, Mr. Worthen having been one of his assistants.

1854. Two paleontological papers, with plates: 1.—"Notice of Producti," etc., "with Descriptions of Twelve New Species." 2.—"Notice of the Genus Chonetes," etc., "with Descriptions of Eleven New Species." By J. G. Norwood and Henry Pratten.—Journal of the Academy of Natural Sciences, Philadelphia.

1855. "Notice of Fossils from the Carboniferous Series of the Western States," etc., "with Descriptions of Eight New Characteristic Species." By. J. G. Norwood and Henry Pratten.—Journal of the Academy of Natural Sciences, Philadelphia.

1868. "Experimental Exercises and Problems in Elementary Chemistry." Published by U. P. James, Cincinnati.

*Dr. J. Lindahl, late curator of the Illinois State Museum, has informed me that he was surprised upon looking over the Illinois collection to find that Dr. Norwood had collected such a large lot of specimens. Both Owen and Swallow forty years ago wrote complimentary letters to Norwood concerning the collection.

[CRUCIAL POINTS IN THE GEOLOGY OF THE LAKE SUPERIOR REGION. No. 6.]

THE KEWEENAWAN ACCORDING TO THE WISCONSIN GEOLOGISTS.

By N. H. WINCHELL, Minneapolis, Minn.

Concisely it may be said, at once, that the Wisconsin survey immediately reached definite ideas on these mooted questions of Lake Superior geology. That survey continued from 1873 to 1879, a period of six years. The whole state was reported and mapped in an incredibly short space of time. Its proximity to Michigan, where many of these rocks had been described, aided the geological corps in no small degree. They were aided still further in having the coöperation and active service of Prof. C. E. Wright and Maj. T. B. Brooks of Michigan, the latter already familiar with the problems involved, and the former still concerned with Michigan geology.

The conclusions of this survey are summed up by Prof. Chamberlin in volume I of the final report, published in 1883. In general they are based on facts reported by the other geologists and published in other parts of the final report. They are as follows, so far as they bear upon the questions we are considering:

1. The Laurentian embraces gneiss and crystalline schists, micaceous and chloritic, and allied rocks.

2. The Huronian is non-conformable upon the Laurentian, embracing all the known iron ore deposits, made up of quartzytes, black slates, often micaceous diorytes, limestones, conglomerates and cherts, having a total thickness of at least 13,000 feet. Quartz-porphyries overlie the quartzytes in central Wisconsin. These members constitute what has later been styled Upper Huronian, and are made the equivalent, after Selwyn, of those extensive deposits in Canada consisting of limestone, iron ores and carbonaceous shales, which were formerly classed with the Laurentian but have been separated from it by Selwyn, as portions of the Huronian. It is non-conformable, but not strikingly so, with the overlying Keweenawan. It is associated with intrusive masses of granite, gabbro and dioryte.

This conception of the Huronian is greatly different from that entertained by Brooks and Irving, who divided it into twenty parts, and included in it the crystalline schists and the Archean greenstones.

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p. 473. 1892.

† Lake Superior. Mon. v, U. S. Geol.

3. The Keweenawan consists essentially of eruptive materials, but toward the top has interstratified fragmental beds, such as conglomerates, sandstones and shales, the aggregate thickness being from 40,000 to 45,000 feet, three-fourths of which is igneous material. The lowest member consists of a great thickness of diabase and allied igneous rocks. The conglomerates consist almost wholly of porphyry pebbles, which cannot be certainly referred to their native sources. One conglomerate is 1,200 feet thick. The trap beds are tilted sometimes to angles of 45 degrees and greater, the immediately overlying sandstones having a conformable dip. After the Keweenawan there was an interval of erosion. The whole period of the Keweenawan was accompanied by subsidence of the region of lake Superior. This is proved by the enormous thickness of the deposits. The subsidence was also accompanied by flexure and faulting.

4. After the Keweenawan was elevated and broken there supervened a period of erosion, during which the region was a land area. This was the time of the Taconic or Lower Cambrian, the sediments of which are found on the Atlantic seaboard. Then the sea returned slowly over the region, depositing a non-conformable sandstone upon the upturned beds of the Keweenawan.

5. This non-conformable sandstone is the Potsdam, and its distinctness from the Keweenawan is not a matter of doubtful opinion. Its accumulation was also accompanied by continued subsidence.

From Nos. 1 and 2 of these general conclusions the writer has no reason to express essential dissent. He wishes here only to call attention to the discriminating foresight of Prof. Chamberlin in not accepting the expanded Huronian of the Canadian geologists, though it was advanced by Irving and Brooks in the same report. The strata which Prof. Chamberlin accepts as typically "Huronian" are those of the Penokee range, which, except the cherty limestone, are by Van Hise classed as "Upper Huronian" in the correlation paper *Archean and Algonkian*, and which at a later date Irving considered, rightly, the equivalent of the Animikie and of the original Huronian. The principal correction in the Huronian of Prof. Chamberlin, which later study has shown to be necessary, is

the separation of a part of the iron ores from the Penokee series and the relegation of them to the greenstone and perhaps to other horizons of the Archean. This would also necessitate the recognition of a non-conformity at the base of his Penokee series, by which that series would be likely to occur transversely and non-conformably on all the parts of the Archean, including many of the so-called diorytes, which are really phases of the greenstones. There is still much doubt as to the true place of the basal limestone of Chamberlin's Penokee series, since Van Hise has latterly included it in the Lower Huronian, thus placing it below the great non-conformity instead of above it where it had uniformly been classed before.*

We desire, however, to call attention to Nos. 3, 4 and 5 of these conclusions, and to examine the evidence on which they are based, as they are the same as expressed by Messrs. Walcott and Van Hise in the two "Correlation papers" to which reference has been made.

No. 3, of Chamberlin's summary, defines the Keweenawan and gives its essential structural relations. As to the nature of the Keweenawan, later examinations have rendered necessary a slight reconstruction of this description. Instead of having an enormous diabase mass at its base, or a gabbro mass, the base consists of fragmental materials. Prof. Irving refers to this fact in his later work on the Keweenawan,† saying that layers of conglomerate and sandstone extend nearly to the base, the conglomerates being generally of acid eruptive rock, such as felsytes, quartz-porphyries and augite syenites. He refers also specially to the light-colored and marly sandstones of the region of Black and Nipigon bays, on the north shore, which lie non-conformable upon the Animikie slates and have a thickness of about 1,300 feet according to Robert Bell. These he considers as in the base of the Keweenawan. If he is correct in this there is abundant reason to put the Keweenawan age in the midst of a great sandstone epoch. But we shall find evidence to believe these Black Bay and Nipigon

*See: Penokee Iron-bearing series of Michigan and Wisconsin. Monograph XIX, U. S. Geol. Sur., p. 473, 1892.

†The copper-bearing rocks of lake Superior. Mon. v. U. S. Geol. Survey, pp. 152, 155, 156, 1883.

sandstones and marls are later instead of earlier than the bulk of the great Keweenawan traps. However, regardless of these, it may be shown that the lowest part of the Keweenawan, as described by Irving, and later by the Minnesota survey and by Prof. Van Hise, consists of massive sandstones and conglomerates. Reference may here be made to the composition of Grand Portage island, in the northeastern part of Minnesota.* At this place is a white sandstone and a conglomerate which show unmistakably that the Keweenawan is separated from the Animikie by an important erosion interval. Below this interval is the upheaved and metamorphosed Animikie, the same that has been examined on Pigeon point by Bayley.† Pebbles from this changed Animikie and from the attendant eruptives (quartz-porphyry and felsyte) are in this conglomerate mingled with pieces of Animikie slate. Over the conglomerate is a white siliceous sandstone. This conglomerate seems to extend for some distance below the water level, since pieces of it having somewhat different characters are on the beach of the island. It has been seen also at other places. A recent re-examination of the valley of the St. Louis river, below Carlton, reveals the existence of remarkable differences in the fragmental conglomerate which there lies on the Archean slates (Keewatin). The lowest portion is a purely quartzose though strongly pyritiferous conglomerate, with pebbles which sometimes are several inches in diameter, becoming gray sandstone above.‡ The materials of this conglomerate are referable wholly to the rocks of the pre-Keweenawan. Careful search did not bring to light a single Keweenawan pebble, although the gabbro hills rise in the immediate vicinity to the hight of over 500 feet. Its structural features indicate a greater age than that of the overlying conglomerate. A finer red conglomerate and red sandstone and shale lie upon the gray conglomerate, and are charged with pieces that can only be referred to the rocks of the Keweenawan immediately adja-

*U. S. Grant, Note on the Keweenawan rocks of Grand Portage island. American Geologist, June, 1894, vol. xiii, p. 437.

See also earlier references to this basal conglomerate by the writer, viz., 16th Minnesota report, pp. 55-56; 18th ditto, pp. 42-43.

†The eruptive and sedimentary rocks on Pigeon point, Minnesota, and their contact phenomena. Bulletin 109, U. S. Geol. Sur.

‡Tenth Minnesota report, p. 33, 1881. Twenty-third ditto, p. 239, 1895.

cent. The lay of the ground and the perpendicular condition of the bluff necessitated a detour away from the river and the manner of union of the red conglomerate with the gray was not observed. This distinction besides was not established, although anticipated, until the specimens collected were subsequently being examined. The most convincing fact tending to show a difference of age between the lower and upper conglomerates, at this place, was the discovery, among the pebbles collected from the upper, of a rounded fragment of iron pyrite which could be directly referred to the pyrite so abundant in the lower conglomerate. The writer was at first disposed to consider the lower conglomerate as the base of the Animikie,* but there is more reason to consider it the base of the Keweenawan and the equivalent of that at the base of Grand Portage island. The upper conglomerate and sandstones must date from Keweenawan or post-Keweenawan time, since they consist almost wholly of Keweenawan débris. If this be correct the Keweenawan age separated the dates of their origin. The upper conglomerate passes upward into the sandstones at Fond du Lac.

Prof. C. R. Van Hise has discovered lately a similar fragmental base for the Keweenawan in Michigan.† It occurs also in Wisconsin. He describes it in one place as the top of the Penokee series, though that is a very anomalous assignment for such a conglomerate, and in another he makes it the base of the Keweenawan. This conglomerate, according to his description, is siliceous and coarsely pebbly, and contains only material that can be referred to pre-Keweenawan rocks. It is associated with a "red sandstone or quartzyte," and is "mingled with Keweenawan greenstones."

Nos. 4 and 5 of Chamberlin's summary (above) are so closely related that they may be considered together, especially so as we do not wish here to call in question the Potsdam age of this upper, or "Eastern sandstone." They appertain to the structural features of the Keweenawan.

Keeping in mind the fact that, as above shown, the Keweenawan was introduced not by eruptions of igneous rock, but

*See Twenty-third report of the Minnesota survey, p. 239.

†The Penokee Iron-bearing series of Michigan and Wisconsin. Mon. XIX. U. S. Geol. Sur., pp. 326, 456-457.

by subsidence of the region by which the Animikie and its modified beds and associated gabbros, red granites and felsytes, were covered by the ocean, it is apparent that the great eruptions of the period began in the midst of the formation of a sandstone. The flexures that were the attendants of this subsidence and eruption were very great. In some places the very rocks themselves which constitute the predominant feature of the Keweenawan were broken and violently scattered, either by erosive action or by volcanic ejection, probably by both. The formation of a conglomerate, which Irving reports as 1,300 feet thick imbedded in the typical Keweenawan on Montreal river, was not the event of a year nor of a century. Several fragmental beds occur on the north shore of lake Superior interstratified in the series. How far they continue as independent strata is not known, but it is very probable that they have a general parallelism with those found on the south shore. The sandstones become conglomeratic. Indeed the wide dissemination of coarse material, especially of felsitic and red-porphyritic rock, during the time of the Keweenawan is one of the most common features of its fragmental strata. It goes, therefore, without saying that the existence of Keweenawan conglomeratic material is not, *per se*, any proof of pre-Keweenawan time, nor evidence of the existence of a great erosion-plane of sufficient significance to warrant the introduction of an important time interval. Yet it is just such evidence as this and an occasional non-conformity which forms the basis of the assumption that the sandstones which are seen non-conformable on the traps at sundry points are of an age widely different from the traps.

In order to make it clear what value the individual cases may have it will be necessary, in the next place, to examine the reports which have been published concerning them. Some of these descriptions omit important data, perhaps because not obtainable. In some cases later examinations have supplied these missing data, but in others they are lacking still.

The St. Croix Falls case is perhaps the most frequently referred to. Prof. Irving depended on this to establish the enormous erosion interval between the traps and the overlying sandstone and inferentially to prove such an interval between

the Lake Superior sandstone and the sandstones of the upper Keweenawan. It is true that the St. Croix beds there lie on the trap, the base of the former being a coarse conglomerate made up largely of trap material from the trap range. There are, however, some important considerations, relating to this occurrence, which are usually overlooked, viz.:

The overlying non-conformable strata at St. Croix falls are not of the age of the Lake Superior sandstone, but younger, although probably a part of the same great formation. The fossils that are found in the strata are those that characterize the horizon of the St. Lawrence limestone, which is the horizon of the original Dicellocephalus. The strata are, in part, not a sandstone, but a dolomyte, and below them, further south, are about 1,000 feet of siliceous sandstone. These lower layers were penetrated in sinking the deep well at Stillwater. They are well known both toward the east, in Wisconsin, and toward the west, in Minnesota, where they have been named Dresbach and Hinckley sandstones. It is these lower sandstones that appear on the Lake Superior shore involved with the traps. The facts at St. Croix falls demonstrate that the subsidence which was going on during the time of the typical Keweenawan and later was yet in progress during the deposition of the St. Croix formation, and that whatever fractures there may have been, in the Keweenawan rocks, incident to the movements of the crust in that region, were covered by the later sediments non-conformably. The St. Croix strata are very far above the base of the sandstone formation, and it is necessary to find the base and show it is a non-conformable conglomerate to warrant the assumption of a great erosion interval after the Keweenawan. This important element is lacking in several other similar non-conformities, if not in all of them so far as described.

Prof. Chamberlin refers specifically to the phenomena at the falls of Black river in Douglas county, Wis., described by Mr. Sweet.* But there is here nothing to prove the horizon of the non-conformable sandstones. They are assumed to be later than the sandstones overlying and tilted with the traps. But the descriptions and the figures of Mr. Sweet do not make that a necessary relation. Indeed one of Mr. Sweet's figures

*Geol. of Wisconsin, vol. III, pp. 340-347.

(fig. 3) shows diabase overlying conglomerate and interstratified sandstone. Between them is an obscure breccia. This conglomerate and sandstone dip 29° southwesterly toward a diabase cliff about 50 feet distant which rises 40 feet. Some of the sandstone outcrops in the gorge are "indurated," as if by igneous contact. In general, however, the interpretation by Mr. Sweet sustains the view taken by Prof. Chamberlin. In the light of observations, however, some of which have been mentioned above, going to prove the pre-existence of conglomerate and sandstone, the facts that have been published relating to this locality will warrant the supposition that here we have to deal with two sandstones and two conglomerates, one pre- and the other post-Keweenawan, and the remark of Mr. Sweet that in one of the conglomerates, i. e., the more friable one, some of the pebbles are themselves of a conglomerate, much strengthens this hypothesis. The contrary dip of the conglomerates also sustains it. There can be no question, however, that the upper sandstone and conglomerate are later than the diabase at that locality. This seems to be proven by the existence of diabase pebbles disseminated through their fragmental materials as well by the difference of dip. How much later is not known. It may have been formed very soon after the intrusion and tilting of the diabase. Whatever its date, the fractured and tilted condition of its beds, as described by Mr. Sweet, goes to demonstrate that the crustal movements, whether upward or downward at this point, had not ceased, but that on the contrary the same instability which is recorded at the St. Croix falls prevailed here probably at an earlier date. The pressure and crushing here were such as to produce a dip in the horizontal sandstones of over 40°, and in other cases to obliterate their bedding and to cause a slaty cleavage and a micaceous grain.* It is very evident that a re-examination of this locality might throw more light on the relations existing between the traps and the sandstones. The lowest beds of the sandstone seem not to be visible.

In reference to the southern side of Keweenaw point, to which Chamberlin refers for further confirmatory evidence, it

*See Irving's description of this locality, Wis. Acad. Sci., vol. II, p. 118, 1874.

is difficult to ascertain what can be relied on as to the interpretation of this shore. Chamberlin and Irving, in Bulletin No. 23 of the United States Geological Survey, admit that the Eastern sandstone in some places passes below the trap rocks of Keweenaw point, as first shown by M. E. Wadsworth, but they claim that this is illusory and only local, and that the eastern sandstone is really non-conformable upon the traps. They explain the structural relations as understood by them by a hypothesis which in itself presents inherent difficulties. It may be that the contrariety of fact and interpretation can be adjusted by allowing two sandstones on the south side of Keweenaw point, one being older than the traps as represented by Rominger and Wadsworth, and one younger, but both embraced in the same great sandstone period, separated locally into two parts by the Keweenawan eruptives.* Indeed, there are some facts, admitted by Chamberlin and Irving, which seem to require this conclusion. We do not, however, consider it important here to decide between these opposite "views," since whether the Eastern sandstone be older or later than the traps there are four important points well established and admitted by all observers, to which attention may be directed, which have bearing on this discussion.

1. Since the Eastern sandstone was deposited there have been considerable, and perhaps very extended, crustal movements which have bent and broken the Eastern sandstone. This is but a repetition of the conclusion that has been drawn from occurrences in Douglas county, Wisconsin, and elsewhere.

2. Whether the Eastern sandstone was flexed upward or downward by such movements, the tilting was abrupt and accomplished within a few hundred yards of the contact plane.

3. There are sandstones that pass, both abnormally because of overthrust, and naturally because of normal infraposition, below the Keweenawan traps. (Bull. 23, pp. 66, 67.)

4. The basal beds of the Eastern sandstone are not here exposed.

The foregoing are the localities to which Chamberlin refers for support for the structural relations affirmed in his sum-

*Those who desire to ascertain the facts that have been relied on for the different theories of the relations of these rocks on the south side of Keweenaw point will find them ably presented and discussed in Bulletin No. 23 of the United States Geological Survey, by Chamberlin and Irving. See also an editorial review in the AM. GEOLOGIST, vol. 1, page 47.

mary in volume I of the Wisconsin survey report. Prof. Van Hise has since reviewed this subject.* While he employs the same data he has also mentioned one other. It is the non-conformable position of the sandstone near Agogebic lake upon the rocks of the Penokee series. The conglomerate here contains rolled pebbles from the Archean, from the Penokee series and from the Keweenawan, the last, consisting of "quartz porphyry and certain phases of basic eruptives," being considered proof that this sandstone here is of later date than the Keweenawan. Admitting the references of all the pebbles as expressed by Van Hise and their significance, there is lacking still that same element which has been found wanting in several other similar cases, viz.: Is this conglomerate at the bottom of the series? It is evident that in a region which is subject to prolonged progressive subsidence the same fragmental series may form a conglomerate in contact with various terranes as the ocean advances. This would show non-conformity on each of them. But this circumstance does not prove non-conformity upon the beds nearest related in time to the transgressing formation. In order to prove an erosion interval preceding such transgressing formation it is necessary to find its lowest beds to be composed of a conglomerate and that they lie non-conformably upon the strata that next preceded the disturbance in point of time. In the case of an eruptive age it is hardly sufficient to find simply some of the upper parts of a sandstone non-conformable upon some of the earlier parts of the same formation to warrant the assertion of a long land interval between those extremes.

Further, the origin of the supposed Keweenawan pebbles is not so certainly established as would be desirable to prove the post-Keweenawan age of this conglomerate. If the situation be considered a moment it appears that the quartz-porphyry pebbles may have been derived from the south. The pebbles from the southern complex must have come from the south. That shows the existence of powerful drift from that direction. According to the Wisconsin geologists there is a large amount of quartz-porphyry associated with the "Archean" quartzytes further south.† These probably are higher in the

*The Penokee iron-bearing series of Michigan and Wisconsin. Mon. XIX, U. S. Geol. Sur.

†Geology of Wisconsin, vol. II, pp. 249, 520.

series than Archean, but whatever their age they are likely to occur at many points throughout the area of the southern complex, or surrounding it, and there would in that case be no plausible reason to exclude their débris from that conglomerate. As to the basic eruptives in this conglomerate it would probably not be questioned that they may have been derived from the volcanics of the "Penokee series" lately described by Van Hise in that immediate neighborhood.* The additional case, therefore, cited by Van Hise, seems not to strengthen the hypothesis of the separateness of the Eastern sandstone from the Keweenawan. In the light of what is now known of the wide extension of a basal siliceous conglomerate at the bottom of the Keweenawan, it seems to the writer quite reasonable to refer this conglomerate to that horizon—especially so since all those conglomerates in the Lake Superior region that can be referred unmistakably to a higher horizon in the series consist wholly, or largely, of Keweenawan débris. Its persistence after the erosion and recession of the Keweenawan trap range to its present line of strike might be reasonably expected for many miles further south. It must have been affected, and perhaps at first covered by the diabasic floods, and so hardened that in its low lying positions it would be almost as durable as the neighboring granite.

Finally, it may be said that all the cited individual cases of non-conformity are defective as proof of an extended erosion interval between the upper part of the Keweenawan, which consists of sandstones quite similar to the horizontal sandstones, and those horizontal sandstones. According to Irving's estimate the upper fragmental member of the Keweenawan rocks, in which no trap layers are found, consists of sandstones and shales, usually reddish, which reach the aggregate thickness of 12,000 or 15,000 feet.† It is claimed on the foregoing evidence that between these and the horizontal sandstones the age of the Taconic, or Lower Cambrian, must be included. This is the fundamental idea on which the whole structure of the "Correlation papers" of Walcott and Van Hise is based so far as they discuss the geology of this region.

*Bulletin Geol. Soc. Am., vol. v, p. 425.

†Copper-bearing rocks of lake Superior, Mon. v, U. S. Geol. Sur., p. 151.

On it Mr. Walcott has based a reconstruction of the Keweenawan, or "pre-Cambrian" continent, and, later, has calculated the age of the world on the hypothesis that the sediments were accumulated in accordance with its shore-lines, while the interior of the continent was elevated above the ocean* and was again submerged.

SUPERIOR MISSISSIPPIAN IN WESTERN MISSOURI AND ARKANSAS.

By Charles Rollin Keyes.

It has long been thought that in the western part of the Ozark uplift the Lower Carboniferous rocks do not present a succession that can be readily paralleled with the more widely and better known sequence exhibited at the eastern extremity of the elevation. Along the Mississippi river, where the typical section of the Lower Carboniferous rocks of the continental interior may be regarded as occurring, there are now recognized four principal members: the (1) Kinderhook, (2) Augusta, (3) St. Louis and (4) Kaskaskia. It has been generally considered that the last two of these are unrepresented in southwestern Missouri and on the western flank of the Ozarks, and it was this absence of the upper members of the series that gave the Lower Carboniferous of the district its apparently anomalous characters.

Until quite recently very little more than the mere presence of Mississippian rocks has been known in southwestern Missouri and northwestern Arkansas. When the region first began to be studied with some detail a few years ago an entirely new classification of the rocks was proposed, new names were given to the different members and no attempts were made to correlate the latter with the better known rocks of the same age further to the east. This radical departure from the usual classifactory scheme was due partly to a change in the lithological characters of the strata, partly to a misinterpretation of facts and partly to insufficient familiarity with the nearest beds of like age along the Mississippi river.

*The North American Continent during Cambrian time, 12th Annual Report U. S. Geol. Survey, 1890-91. Plates XLII and XLIII; Correlation Papers, Bulletin 81. 1891. Plates II and III; Geologic Time, as indicated by the sedimentary rocks, Am. Geologist, vol. xii, p. 343.

In geographical extent the rocks of the Mississippian series present some striking peculiarities which have an important bearing upon the question of the range and character of the contained faunas. Beginning in north-central Iowa near the Minnesota line, where the Carboniferous passes beneath the Cretaceous, the Mississippian rocks extend southeastward in a broad belt to the river from which the formation takes its name. From southern Iowa the Lower Carboniferous limestones continue southward along the great stream on the eastern border of the Ozark uplift and sweep through Kentucky and Tennessee into Alabama. In northeastern Missouri another zone stretches around the northern and western flanks of the uplift through southwestern Missouri, northwestern Arkansas and Indian Territory, extending, discontinuously probably, as far as New Mexico.

The Lower Carboniferous rocks which are exposed along the Mississippi river were carefully studied and the fossils and succession of beds clearly made out long before any other portion of the area had been satisfactorily determined. It was on this account and for the reason that the rocks of this age are so excellently and fully exposed on the stream that it became eminently proper to designate the strata as the Mississippian series. The section disclosed thus becomes the principal one and the standard of comparison. To it sections of different localities in the interior basin must be referred and with it all correlations made.

A review of the geological work done previous to 1891 in southwestern Missouri and the adjacent territory shows clearly that not only difficulties of interpretation were encountered but that no serious attempts were made to compare the succession with those of other localities. The want of details and the uncertainty which surrounded the various accounts of the region have been in great measure relieved by recent personal visits to some of the more important localities. The inferior portion of the Lower Carboniferous was found to be as fully developed and as clearly defined as in the typical localities in southeastern Iowa. The superior portion of the series—that part comprising the St. Louis and Kaskaskia limestones—did not appear to be represented. Only a few of the localities examined gave evidence of the higher faunas and none of these were conclusive enough to settle the question satisfactorily.

In order that the sections in southwestern Missouri might be accurately correlated with the typical localities as a basis for future detailed work, the Lower Carboniferous strata were carefully traced from Iowa southward along the eastern border of the state, all the original localities were examined in detail and full collections of fossils made. From northeastern Missouri the strata were similarly traced across the state into the southwest. The Kinderhook, upper Burlington and lower Burlington limestones were found to extend the entire distance with almost no lithological or faunal change. But with the Keokuk and higher formations of the Lower Carboniferous, which are so well displayed in southeastern Iowa, some startling facts developed in progressing southwestward. After passing the Missouri river where, at Boonville, these rocks occur with abundant and characteristic fossils, the Keokuk beds soon vanished. At Sedalia and for fifty miles beyond no Keokuk or higher beds of the Lower Carboniferous limestone appeared to be exposed; and the Coal Measures rested directly upon the Burlington. This was indeed clearly demonstrated by Broadhead* nearly a quarter of a century ago. It is at this part of its southwestern extension, in Pettis, Benton and St. Clair counties, that the Lower Carboniferous zone abruptly narrows from a width of 75 miles on the north and the south to less than a dozen miles. At some points the belt is reduced to a mere thread, as it were, that is, with only a limited vertical exposure disclosed by some stream, the Chouteau limestone being below and the Coal Measure shales in the bluffs above. Such a place was at the Osage river. Repeated searches and rather extensive collections of fossils from the various levels failed to disclose anything of the Lower Carboniferous above the Burlington.

Probably the feature which most disguises the Lower Carboniferous rocks of southwestern Missouri is the great prevalence of chert; and in the absence of a careful examination of the fossils much difficulty has been encountered in the interpretation of the stratigraphical problems presented. Furthermore, it is a striking fact that of all the references to the geology of the region under consideration no definite mention

*Missouri Geol. Sur., Report on Iron ores and Coal Fields, Pt. II, pp. 162. New York, 1873.

is made to rocks belonging to the upper half of the Mississippian series. Farther south, in Arkansas, the upper part has been reported, to be sure, but it has not been paralleled with the St. Louis and Kaskaskia formations at the eastern end of the Ozark uplift and a new name has been applied, both members being taken together.

It is therefore of considerable interest that the higher faunas have been recognized recently at a number of points, the principal places being Golden City, Joplin and Seneca in Missouri, and at Blancett mountain, near Garfield station on the St. Louis and San Francisco railroad, in northern Arkansas, three miles from the Missouri boundary line.

The locality near Golden City is three miles northeast of the town, in Dade county, on the border of the Coal Measures. At this place were found large numbers of *Lithostrotion mamillare* the widely distributed coral so characteristic of the St. Louis limestone. In the neighboring county this fossil also occurs along with the widely known echinoid *Melonites multipora.*

At Blancett, Prof. G. C. Broadhead collected, as much as a dozen years ago, a number of fossils, which until recently were not carefully examined and remained unidentified. The species that were most abundant were:

Spirifer increbescens Hall. *Agassizocrinus gibbosus* Hall.
Agassizocrinus dactyliformis Troost.

At a point one and one-half miles north of Joplin a large number of bryozoans and brachiopods have been found. Mr. R. R. Rowley also collected considerable numbers which were examined. Several species of *Chonetes, Terebratula, Rhynchonella, Retzia* and *Phillipsia* were secured but have not been as yet satisfactorily identified. The bryozoans were, moreover, submitted to Mr. E. O. Ulrich, who independently determined all of them as characteristic Kaskaskia forms. The principal species found were:

Agassiocrinus dactyliformis Troost.
Agassiocrinus gibbosus Hall.
Spiriferina spinosa Hall.
Athyris sublamellosa Hall.
Productus parvus Meek & Worthen.
Rhombopora persimilis Ulrich.
Meekopora approximata Ulrich.
Prismopora serrulata Ulrich.
Prismopora, sp. nov.
Streblotrypa nicklesi Ulrich.
Streblotrypa subspinosa Ulrich.
Septopora subquadrans Ulrich.

Productus setigerus Hall.
Stenopora ramosa Ulrich.
Anistrypa solida Ulrich.
Anistrypa fistulosa (Kaskaskia variety.)
Batostomella abrupta Ulrich.
Polypora corticosa Ulrich.
Fenestella cestriensis Ulrich.
Fenestella flexuosa Ulrich.
Archimedes compactus Ulrich.
Archimedes intermedius Ulrich.
Archimedes invaginatus Ulrich.

The Seneca specimens are not now at hand and a list of them cannot now be given.

The fossils taken indicated clearly that they belong to the Kaskaskia fauna. The crinoids and bryozoans are particularly characteristic species of the typical locality of that formation on the Mississippi river, and are also widely distributed forms which range through Kentucky and beyond.

These limited deposits of Kaskaskia rocks are clearly remnants of beds which were once much more widely distributed but have been almost entirely obliterated through erosion. Further south in the Boston mountains of northwestern Arkansas they are thought to be extensively developed.

From what has been said it may be inferred that, in southwest Missouri:

1. Both the inferior and superior portions of the Mississippian or Lower Carboniferous are present.

2. In faunal, lithological and stratigraphical features the Burlington limestones are practically the same as at the typical locality and that throughout this wide range their characteristics are remarkably well preserved.

3. The upper part of the superior portion of the Lower Carboniferous is not well represented and is altogether absent over much of the area.

4. The uppermost member of the series contains the typical Kaskaskia fauna.

5. The Coal Measures rest unconformably on all the older strata represented in the district, and in the vicinity of Sedalia and to the southward the overlap is very much more pronounced than elsewhere.

The explanation of the somewhat anamolous features presented by the Lower Carboniferous formations of southwest Missouri is found in the stratigraphical rather than in the faunal evidence. Further, the physical changes that the region has undergone are corroborated by the phenomena which are known to have taken place in other parts of interior basin.

It is now pretty well established that ever since the earliest times, from the period when the North American continent first began to raise itself above the boundless sea, the Ozark region has been a district of constant movement.

In the Carboniferous rocks which are exposed in almost continuous section for nearly 300 miles along the Mississippi river the records of a number of oscillations have been recently made out. Immediately preceding the deposition of the Lower Carboniferous there was certain slight uprisings. Notable warpings of the earth's crust also took place at the beginning of the St. Louis, of the Kaskaskia and of the Coal Measures. The idea of a line of unconformity existing at the base of the St. Louis was first brought out by White. It has later also been suggested by Williams for Arkansas. At the top of the St. Louis exists the most prominent disparity in sedimentation, one only approached by that at the base of the Coal Measures. Along the line of the present Mississippi river the shore line moved rapidly southward far beyond any point previously reached and littoral deposits were laid down below the mouth of the Missouri. A similar sequence of events appear to be disclosed in southwest Missouri.

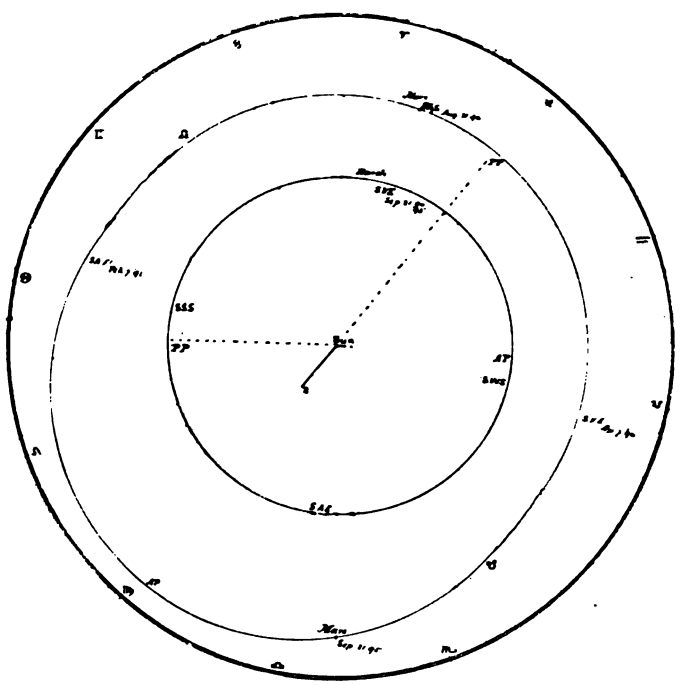
GLACIAL NOTES FROM THE PLANET MARS.

By E. W. Claypole, Akron, Ohio.

In connection with the much discussed Glacial era of our planet's history it would be of great interest to obtain definite knowledge of the possibility or reality of similar conditions on some other planet in our system. Nor does such knowledge seem altogether unattainable, though one planet alone thus far has afforded the slightest prospect of success in the effort to secure it. Mars has, ever since telescopes of sufficient power were first turned to his disc, presented to the eye appearances so strongly suggestive of that which our earth would present to a Martian astronomer as to inevitably suggest a comparison, if not a resemblance. It is indeed difficult to avoid the conviction that the white masses on the poles of Mars as they emerge from their long winter are really snow-caps. Their constant occurrence, their regular seasonal diminution during the past two hundred years as the poles alternately come out into the strong sunlight, and the total disappearance of one of

them, for the first time since observations began, during the last Martian summer of 1894, form an argument so strong as to be almost demonstrative in support of this long entertained opinion. They bring this planet, our nearest superior neighbor in the system, into very close analogy with our own globe.

It is scarcely relevant to conjure up theoretical objections drawn from possible but imaginary differences between the physical constitution of the earth and Mars. Not the slightest grounds exist for supposing such differences. The community of material through the universe is so well proved and the absence from the other planets of all elements other than those with which we are familiar justifies us in assuming identity and in believing that the white caps of Mars are composed of real snow and ice.



EXPLANATION OF DIAGRAM.

Projection of the orbits of the Earth and Mars on the plane of the Ecliptic.
PP. Perihelion point. Earth 100° Long. Mars 335° Long.
SVE. Southern Vernal Equinox. Mars 354° Long.
SSS. Southern Summer Solstice.
SAE. " Autumnal Equinox.
SWS. " Winter Solstice.
S 1. Eccentricity of orbit of Earth.
S 2. " " " " Mars.

The recent opposition of Mars has been industriously utilized by various astronomers in securing observations under very favorable circumstances. As may be seen from our figure, Mars and the earth can seldom be better placed for this purpose than they were during the summer and autumn of 1894. Mars being in perihelion and the earth at mean distance, the two globes were coursing along through space side by side with an interval of less than 50 million miles between them. Moreover, the illumination of Mars was at a maximum, the bright side being directed toward the night side of the earth so that he was visible from sunset to sunrise for several months.

This admirable opportunity of scrutinizing the surface of our neighbor planet led to the confirmation of some previous opinions and the discovery of not a few details. From various sources the following account of our present knowledge and belief, as based on the researches of past and present astronomers, has been compiled.

As already mentioned, the polar snows annually melt and diminish, and during the recent Martian summer the southern snow-cap entirely disappeared evidencing an unusually hot season. During its diminution there was seen bordering it a dark band of unequal breadth, but averaging in June, 1894, about two hundred miles. "It was the darkest marking on the disc and was blue." (Lowell.)

The snow-cap extended down to $67\frac{1}{2}^{\circ}$ south latitude so that the dark boundary band was at least 6° in width and its northern end lay in south latitude $61\frac{1}{2}^{\circ}$. Of it Mr. Lowell of the Flagstaff Observatory in Arizona says: "The formation was water beyond a doubt, for it was of the color of water, it faithfully followed the melting of the snow, and it subsequently vanished—three independent facts mutually confirmatory of this conclusion."

Following the appearance of the water band, says Mr. Lowell, the well known system of Martian canals shares in the deepening of the color but temporarily and in south-north succession. The so-called seas through which the canals pass share also in the change of tint. Gradually this dark hue spreads toward the planet's equator. One after another the markings on the surface become blue-green and in similar or-

der pass back in a short time to their original yellow color or invisibility.

On the view advocated by Mr. Lowell the melting of the south polar snow-cap produces a glacial lake extending from the ice-front for two hundred miles to the northward and probably deepest where it is in contact with the ice. The steady increase of the lake at last enables it to throw off its water through the so-called "canals," and with the arrival of these streams the growth of vegetation commences and gives the blue-green tint so much insisted on by that author. With the disappearance or great reduction of the polar cap the water disappears, vegetation dies and the surface of the planet returns to its wonted fiery tint. In Mr. Lowell's words the polar ice-dammed sea is the "Deus ex machina" to the summer life of the planet. Mars being short of water draws on its polar reservoir for an annual supply.

Mars would on this view be in the same condition as some of the arid regions of the earth where a short wet season develops an equally short-lived period of vegetation and perhaps of animal life. The so-called seas would be the lowest parts of the surface through which water passes at annual intervals but in which it does not continually remain. With his scanty allowance of air and water the planet shows a stage of being considerably more advanced than that of our own earth where water is still almost everywhere abundant and air the cheapest necessity of life. This is in keeping with what might be expected from his great distance from the sun and his smaller size. Internal cooling may be assumed to be more nearly complete.

There is no doubt concerning the excessive tenuity of the Martian atmosphere. Delicate tests have many times failed to detect it and this fact has led to the denial of its existence by many observers. But the peculiar hazy appearance that veils the structural details near the edge of the planet's disc justifies Mr. Lowell in the conclusion that a thin atmosphere of some kind must exist. And if we admit the presence of water as shown above, there must certainly be, at least locally and temporarily, an atmosphere of water-vapor of tension varying with the temperature. Assuming other conditions as on the earth, this tension would at 32° Fahrenheit equal 0.2

inches of the mercurial barometer, and at 80° Fahrenheit it would equal an inch. One curious effect that must follow is the rapid transfer of the vapor from the sunny to the shady side of the planet. The rapid evaporation that must accompany the high temperature of the Martian summer day must produce an aqueous atmosphere of considerable tension which must immediately flow off, more or less completely, to the opposite hemisphere and then condense, probably at once, to the solid form. If, as Schiaparelli says, the northern snow-cap does not begin to increase until a month after the occurrence of the northern vernal equinox, it follows that the shady side of the planet cannot be intensely cold or that the quantity of water thus transferred is not very great. Both conclusions are probably true. Possibly the condensation of the vapor near the edge may in part cause the haze there noticed.

There can be no doubt that of whatever material the assumed atmosphere may consist it is exceedingly rare in comparison with our own. Mr. Lowell concludes that "in constitution it does not differ greatly from our own and that it is heavily charged with water-vapor, but that its density is less by a half than that of the air at the summit of the Himalayas." This would equal a mercurial column (on the earth) of about three inches. Under such conditions movement would be easy and the transfer of gas or vapor from place to place exceedingly rapid.

From what has been above said it is obvious that no true glacial conditions exist on Mars at present. His polar snow-caps form regularly every twenty-two months and have done so for two centuries past. But they never extend beyond the frigid zones of the planet and with the returning sun of summer they waste and dwindle, and, as already mentioned, that on the south pole has actually disappeared during the just ended southern summer. Not so with the earth. Observation fails to show any marked reduction of the Antarctic ice-cap during our Antarctic summer. It is true that the corresponding season on Mars is ten months long instead of six. But we must bear in mind that the corresponding winter lasts through a whole terrestrial year. It is, however, possible that water on Mars is so scarce that no great addition could be made to the polar ice-fields by any increase in the length of the winter.

The relative distances of the earth and Mars from the sun being as 1 : 1.5, the light and heat that they receive is in proportion to 9 : 4. Consequently the sunlight and sun heat on Mars are a little more than half as strong as that we feel. Yet in spite of this diminution his polar regions are kept above the freezing point throughout the summer and his polar ice nearly or altogether disappears. The excessive tenuity of his atmosphere, rendering cloud and fog almost impossible, may combine with the scarcity of water above mentioned to produce this result.

The aqueous vapor of which his atmosphere may in great part consist is a third factor in the problem. By retaining near the surface of the planet the reflected solar heat the temperature of the lower layers must be considerably raised by day and their cooling by radiation equally reduced at night. The combined result is apparently to render the Martian climate far from intolerable during the summer, and the continued flow of vapor and its condensation must to some degree at least mitigate the otherwise intense severity of the long twelve-month winter.

In considering the glacial relations of Mars it must be further remembered that the eccentricity of his orbit far exceeds that of our own earth at present or that which it has attained at any known epoch in the past. These two amounts are represented by the figures 0.01617 and 0.09326 respectively. The latter is nearly six times as great as the former. The axes of the orbits and the perihelion and aphelion distances of the planets also greatly vary. At the southern summer solstice the earth is about three million miles nearer to the sun than in midwinter. But Mars at the same season is twenty-eight million miles nearer than at his southern winter solstice. One consequence of this is the lengthening of the latter season. On the earth at the present time the southern summer is eight days shorter than the winter, but on Mars the difference in the same direction amounts to 74 days, the planet spending 306 days in the perihelial and 380 days in the aphelial division of its orbit. If the eccentricity were the main cause of glacial climates Mars must then be in a very favorable condition for glaciation. But as it is possible that his eccentricity may yet reach the yet higher figure of 0.14224 these conditions are

not yet at their maximum, for in the latter case the Martian winter can exceed his summer by about 110 days. This would produce a winter of 398 and a summer of only 288 days.

When we recall to mind the meteorological conditions of our own south polar regions it is scarcely possible to doubt that if eccentricity were the dominant factor in producing an ice-age there should be evidence of more extensive Antarctic snows on a planet possessing nearly the same inclination as the earth but an orbit six times as eccentric. On the earth S. Georgia, in latitude 55°, is covered with snow "many fathoms deep at the sea-level and in the height of summer."*

Another fact deserves mention in this connection. According to the "eccentricity theory" the north polar region of Mars should now be enjoying a warm interglacial climate. The inclination of his axis, which in amount is nearly equal to that of the axis of the earth, is such as to bring his north pole into the sunlight during the long aphelion passage of twelve months. Says Dr. Croll in "Climate and Time" (p. 237): "As the cold periods in the southern hemisphere become more and more severe, the ice would continue to advance northwards in the temperate regions; but at that very same time the intervening warm periods in the northern hemisphere would become warmer and warmer and more equable, and the ice of the arctic regions would continue to disappear farther and farther to the north, till by the time that the ice had reached a maximum during the cold antarctic periods, Greenland and the arctic regions would, during the warm intervening periods, be probably free of ice and enjoying a mild and equable climate."

Instead of this, however, we find the north pole of Mars capped with its snow and ice as regularly and almost as extensively as his south pole, and this wintery accumulation lasts as long into the northern summer as does its southern counterpart into the warm season of the southern hemisphere. If any difference existed between the glacial condition of the two planets it should be one that indicates greater intensity both of the cold and warm eras on Mars in consequence of the high eccentricity that now elongates his orbit so far beyond that of the earth.

*Capt. Cook's Second Voyage, vol. II, p. 232, 1875.

It is true that at least one astronomer entertains an opinion radically different from those above summarized and which are shared by most observers. Mr. Holden, of the Lick Observatory, in the North American Review for May, 1895, writes on the spectroscopic observations of Prof. Campbell on Mars during the spring and summer of 1894. From a comparison between the absorption bands shown in the spectra of that planet and the moon this observer draws the conclusion that "there is no more evidence of aqueous vapor or of an atmosphere on the former than there is on the latter. And it is in the highest degree unlikely that Mars has an atmosphere anything like as dense as the earth's atmosphere at the summit of the Himalayas."

Hence Mr. Holden concludes that "the lakes, oceans, etc., have all vanished with the aqueous vapor. It is very unsatisfactory, no doubt, to be unable to answer many questions" regarding this planet, but "it is satisfactory to have taken the very important step of clearing the way by sweeping out of sight the fabric of assumptions that have barred the path."

This iconoclastic opinion is in itself so sweeping and solitary that in spite of its positive tone and the high position of the Lick Observatory we may be excused for declining to accept it without reserve so long as observers equally experienced and equally careful cling to their opposing views. We are the more fully justified in so doing by recalling the fact that Mr. Holden's opinion is qualified with the proviso that "the atmosphere of Mars cannot be anything like as dense as the earth's atmosphere at the summit of the Himalayas," while Mr. Percival Lowell only claims one "less than half of that density, though charged with aqueous vapor." So modified a denial of previous observations is by no means tantamount to disproof.

Morover, several emphatic contradictions of Mr. Holden's conclusions have lately appeared in print. Prof. Huggins and Prof. Vogel have both affirmed in the Astrophysical Journal that a comparison of the spectra of Mars and the moon does show a difference that indicates absorption really due to the atmosphere of Mars. And Mr. Jewell in the same periodical for April last says that unless the amount of vapor in the atmosphere of Mars is greater than that in October in Baltimore

it is useless to look for its evidence in the spectrum with our present means.

In general, therefore, it appears safe to conclude that the polar caps of Mars are really composed of snow and therefore prove the existence of water on his surface,—that they prove a variation of climate with latitude like our own,—that they prove by melting on emergence into sunlight that approximately similar laws control the freezing of water and the thawing of ice there and here.

It is also obvious from what has here been summed up that Mars affords no evidence in support of the eccentricity theory of glacial cold, though his conditions are at present such as to favor a state of intense glaciation in his southern hemisphere. But exactly how far this inference may be modified by the apparent scarcity of water and therefore of snow on the planet is a point not easy at present to be determined. For obviously if the supply of vapor be small no degree of cold or length of winter can produce more than a corresponding quantity of polar snow. For this reason the presence of a north polar snow-cap during an interglacial period is evidence of greater importance.

It is further to be noted in the same direction that we find no evidence whatever of the intenser climate which the eccentricity theory would lead us to look for on the planet Mars. His snow-caps extend no farther south than do those of the earth. Indeed we cannot say that they extend so far. In a severe American winter the snow field is often continuous from the pole to the middle states or to about the parallel of 35° north. Not infrequently the whole northern part of the continent is sheeted in white. Nothing of the kind has ever been seen on Mars. Yet a layer of snow a few inches in thickness would be just as conspicuous as one of greater depth. If also, according to Schiaparelli's observation already referred to, the north polar ice-cap does not form until after the vernal equinox of that hemisphere has passed, the fact shows a surprising power of retaining the heat of the long summer. It would also seem as if the climate of Mars, in spite of greater distance from the sun and the high eccentricity of his orbit, was really milder than our own. And it would be an interesting question in physics, but scarcely cognate with our pres-

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ent subject, to enquire how far such a climate might be induced by the presence of an atmosphere in great part, or almost entirely, composed of aqueous vapor.

CORRELATIONS OF STAGES OF THE ICE AGE IN NORTH AMERICA AND EUROPE.

By WARREN UPHAM, Cleveland, Ohio.

(Plates V and VI.)

Exploration of the European terminal moraines and other drift deposits by two Americans, Prof. H. Carvill Lewis in the British Isles, and Prof. R. D. Salisbury in Germany, less than ten years ago, laid the foundations for determining the geologic equivalency of the successive parts of the drift series in North America and Europe. Salisbury especially noted that the marginal moraines of northern Germany lie, as in the United States, at some distance back from the limits of the drift.

Studies by many observers have shown that on both continents the border of the drift along the greater part of its extent was laid down as a gradually attenuated sheet; that the ice retreated and the drift underwent much subaerial erosion and denudation; that renewed accumulation and growth of the ice-sheet, but mostly without extending to its earlier limits, were followed by a general depression of these burdened lands, after which the ice again retreated, apparently at a much faster rate than before, with great supplies of loess from the waters of its melting; that moderate re-elevation ensued, and that during the farther retreat of the ice-sheet prominent moraines were amassed in many irregular but roughly parallel belts, where the front at successive times paused or re-advanced under secular variations in the prevailingly temperate and even warm climate by which, between the times of formation of the moraines, the ice was rapidly melted away.

Such likeness in the sequence of glacial conditions probably implies contemporaneous stages in the glaciation of the two continents; and the present writer believes that it is rather to be interpreted as a series of phases in the work of a single ice-sheet on each area than as records of several separated and independent epochs of glaciation, differing widely from one another in their methods of depositing drift. The latter view, however, is held by James Geikie, Penck, De Geer, and

others in Europe; and it has been regarded as the more probable also for America by Chamberlin, Salisbury, McGee, and others.

Under this view, Geikie distinguishes no less than eleven stages or epochs, glacial and interglacial, which he has very recently named,* since the publication last year of the new edition of his "Great Ice Age," in which, however, they were fully described. These divisions of the Glacial period are as follows: 1. The Scanian or first glacial epoch; 2. The Norfolkian or first interglacial epoch; 3. The Saxonian or second glacial epoch; 4. The Helvetian or second interglacial epoch; 5. The Polandian or third glacial epoch; 6. The Neudeckian or third interglacial epoch; 7. The Mecklenburgian or fourth glacial epoch; 8. The Lower Forestian or fourth interglacial epoch; 9. The Lower Turbarian or fifth glacial epoch; 10. The Upper Forestian or fifth interglacial epoch; and 11. The Upper Turbarian or sixth glacial epoch.

The earliest application of such geographic names to the successive stages and formations of the Ice age appears to be that of Chamberlin in his two chapters contributed to the new third edition of Geikie's admirable work before mentioned, in which he names the Kansan, East Iowan, and East Wisconsin formations. For the second and third he has since adopted the shorter names, Iowan and Wisconsin, which were suggested by a review in the AMERICAN GEOLOGIST (vol. XV, p. 56). This classification he has also more recently extended, the interglacial stage and deposits between the Kansan and Iowan till formations being named Aftonian, and the Toronto interglacial formation being thus named and referred, with some doubt, to an interval between the Iowan and Wisconsin stages. Chamberlin correlates, with a good degree of confidence, his Kansan stage of maximum North American glaciation with the maximum in Europe, which is Geikie's Saxonian epoch: the Aftonian stage as Geikie's Helvetian; the Iowan as the European Polandian; and the Wisconsin or moraine-forming stage of the United States as the Mecklenburgian, which was the stage of the "great Baltic glacier" and its similarly well developed moraines.†

*Journal of Geology, vol. III, pp. 241-269, April-May, 1895.

†Journal of Geology, vol. III, pp. 270-277, April-May, 1895.

According to the law of priority, the names of the Kansan, Iowan, and Wisconsin formations and stages should also be applied to these European divisions of the Glacial series, for the studies of Geikie and Chamberlin show them to be in all probability correlative and contemporaneous. Plates V and VI therefore employ these names for both our own continent and Europe, giving the boundaries of these formations as mapped in "The Great Ice Age," and adding for the northeastern United States and Canada the Warren, Toronto, Iroquois, and St. Lawrence stages in the glacial recession, nearly as indicated in the writer's recent article on the glacial representatives of the Laurentian lakes and on the Late Glacial or Champlain subsidence and re-elevation of the St. Lawrence river basin.*

Differing much from the opinions of Geikie, and less widely from those of Chamberlin, concerning the importance, magnitude, and duration of the interglacial stages, but agreeing with Dana, Hitchcock, Wright, Kendall, Falsan, Holst, Nikitin, and others, in regarding the Ice age as continuous, with fluctuations but not complete departure of the ice-sheets, my view of the history of the Glacial period, comprising the Glacial epoch of ice accumulation and the Champlain epoch of ice departure, may be concisely presented in the following somewhat tabular form.† The order is that of the advancing sequence in time, opposite to the downward stratigraphic order of the glacial, fluvial, lacustrine, and marine deposits.

Epochs and Stages of the Glacial Period.

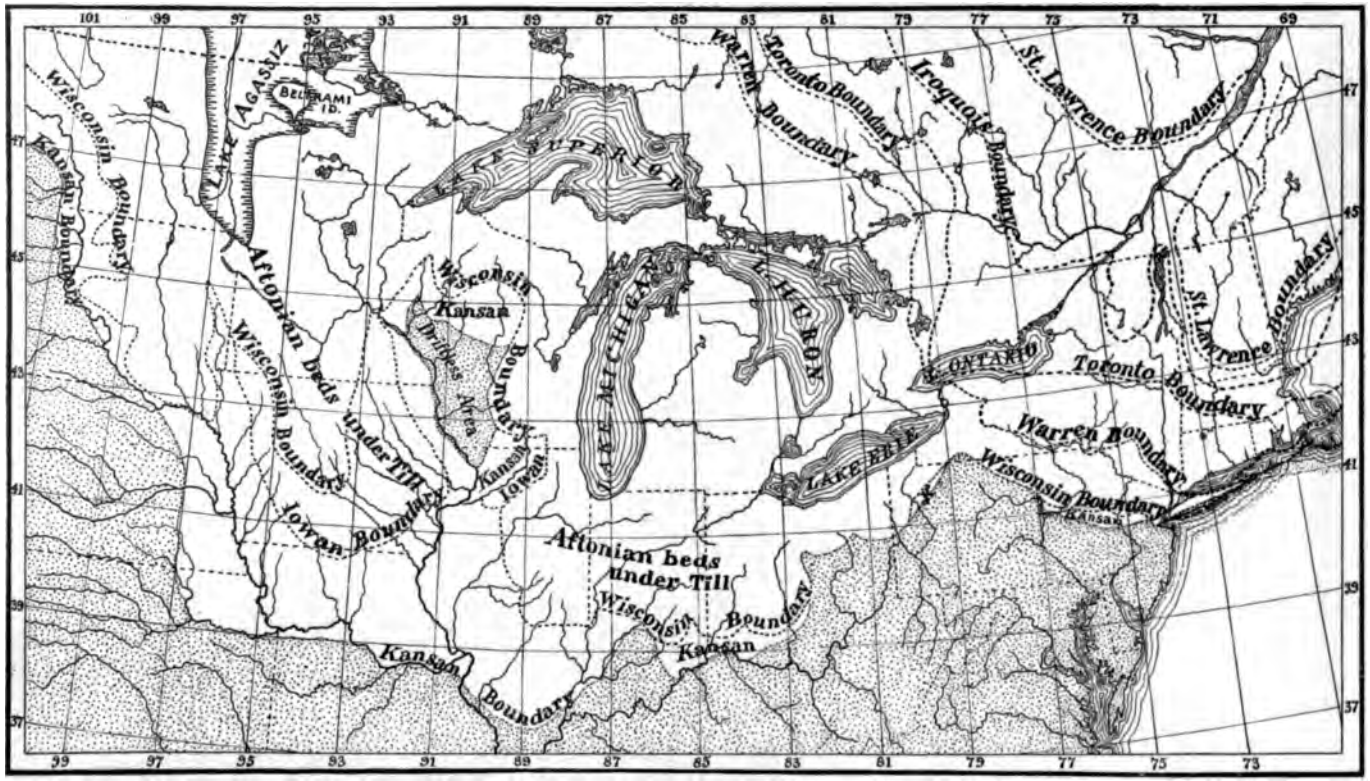
I. The Glacial Epoch.

1. The culmination of the Lafayette epeirogenic uplift, affecting both North America and Europe, raised the glaciated areas to so high altitudes that they received snow throughout the year and became deeply ice-enveloped. Valleys and fjords show that this elevation was 1,000 to 4,000 feet above the present hight.

Rudely chipped stone implements and human bones in the plateau gravels of southern England, 90 feet and higher above

*Am. Jour. Sci., III, vol. xlix, pp. 1-18, with map, Jan., 1895.

†A partial outline of this correlation of North American and European glacial and interglacial stages was first published in the American Naturalist, vol. xxix, pp. 235-241, March, 1895.


Wisconsin Boundary
Kansan Boundary
Lake Agassiz
Beltrami Is.
Lake Superior
Warren Boundary
Toronto Boundary
Iroquois Boundary
St. Lawrence Boundary
Aftonian beds under Till
Wisconsin
Kansan
Driftless Area
Kansan Boundary
Iowan
Iowan Boundary
Lake Michigan
Lake Huron
L. Ontario
Lake Erie
Aftonian beds under Till
Wisconsin Boundary
Kansan Boundary

the Thames, and the similar traces of man in high terraces of the Somme valley, attest his existence there before the maximum stages of the uplift and of the Ice age. America appears also to have been already peopled at the same early time.

The accumulation of the ice-sheets, due to snowfall upon their entire areas, was attended by fluctuations of their gradually extending boundaries, giving the Scanian and Norfolkian stages in Europe, and an early glacial recession and readvance in the region of the Moose and Albany rivers, southwest of Hudson bay.

2. KANSAN STAGE. Farthest extent of the ice-sheet in the Missouri and Mississippi river basins, and in northern New Jersey. The Saxonian stage of maximum glaciation in Europe.

Area of the North American ice-sheet, with its development on the Arctic archipelago, about 4,000,000 square miles; of the Greenland ice-sheet, then somewhat more extended than now, 700,000 square miles or more, probably connected over Grinnell land and Ellesmere land with the continental ice-sheet [the area of Greenland is approqimately 680,000 square miles, and of its present ice-sheet, 575,000 square miles]; of the European ice-sheet, with its tracts now occupied by the White, Baltic, North, and Irish seas, about 2,000,000 square miles.

Thickness of the ice in northern New England and in central British Columbia, about one mile; on the Laurentide highlands, probably two miles; in Greenland, as now, probably one mile or more, with its surface 8,000 to 10,000 feet above the sea; in portions of Scotland and Sweden, and over the basin of the Baltic sea, a half mile to one mile.

3. HELVETIAN OR AFTONIAN STAGE. Recession of the ice-sheet from its Kansan boundary northward about 500 miles to Barnesville, Minn., in the Red river valley; 250 miles or more in Illinois, according to Leverett; but probably little between the Scioto river, in Ohio, and the Atlantic coast, the maximum retreat of that portion being 25 miles or more in New Jersey. A cool temperate climate and coniferous forests up to the receding ice border in the upper Mississippi region. Much erosion of the early drift.

The greater part of the drift area in Russia permanently re-

linquished by the much diminished ice-sheet, which also retreated considerably on all its sides.

During this stage the two continents probably retained mainly a large part of their preglacial altitude. The glacial recession may have been caused by the astronomic cycle which brought our winters of the northern hemisphere in perihelion between 25,000 and 15,000 years ago.*

4. IOWAN STAGE. Renewed ice accumulation, covering the Aftonian forest beds, and extending again into Iowa, to a distance of 350 miles or more from its most northern indentation by the Aftonian retreat, and re-advancing about 150 miles in Illinois, while its boundary eastward from Ohio probably remained with little change.

The Polandian stage of renewed growth of the European ice-sheet, probably advancing its boundaries in some portions hundreds of miles from the Helvetian retreat.

II. The Champlain Epoch.

5. CHAMPLAIN SUBSIDENCE; NEUDECKIAN STAGE. Depression of the ice-burdened areas mostly somewhat below their present hights, as shown by fossiliferous marine beds overlying the glacial drift up to 300 feet above the sea in Maine, 560 feet at Montreal, 300 to 400 feet from south to north in the basin of lake Champlain, 300 to 500 feet southwest of Hudson and James bays, and similar or less altitudes on the coasts of British Columbia, the British Isles, Germany, Scandinavia, and Spitzbergen.

Glacial recession from the Iowan boundaries was rapid under the temperate (and in summers warm or hot) climate belonging to the more southern parts of the drift-bearing areas when reduced from their great preglacial elevation to their present hight or lower. The finer portion of the englacial drift, swept down from the ice-fields by the abundant waters of their melting and of rains, was spread on the lower lands and along valleys in front of the departing ice as the loess of the Missouri, the Mississippi, and the Rhine. Marine beds reaching to a maximum hight of about 375 feet at Neudeck, in western Prussia, give the name of this stage.

6. WISCONSIN STAGE. Moderate re-elevation of the land, in the northern United States and Canada advancing as a perma-

*AM. GEOLOGIST, vol. xv, pp. 291, 255, and 293, March, April, and May, 1895.


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ICELAND
Arctic Circle
Kansan and Iowan Boundary
Wisconsin Boundary
GREAT BALTIC GLACIER
White Sea
Gulf of Bothnia
ASIA
EUROPE
R. Ob
Kansan Boundary
Iowan Boundary
NORTH SEA
BALTIC SEA
Wisconsin Boundary
R. Elbe
BERLIN
BRUSSELS
Kansan Boundary
R. Dnieper
R. Ural
R. Volga
CASPIAN SEA
ALPS
R. Danube
CAUCASUS
BLACK SEA
ADRIATIC SEA
MEDITERRANEAN SEA

nent wave from south to north and northeast; continued retreat of the ice along most of its extent, but its maximum advance in southern New England, with fluctuations and the formation of prominent marginal moraines; great glacial lakes on the northern borders of the United States.

The Mecklenburgian stage in Europe. Conspicuous moraine accumulations in Sweden, Denmark, Germany, and Finland, on the southern and eastern margins of the great Baltic glacier. No extensive glacial re-advance between the Iowan and Wisconsin stages, either in North America or Europe.

7. WARREN STAGE. Maximum extent of the glacial lake Warren, held on its northeast side by the retreating ice border; one expanse of water, as mapped by Spencer, Lawson, Taylor, Gilbert, and others, from lake Superior over lakes Michigan, Huron, and Erie, to the southwestern part of lake Ontario; its latest southern beach traced east by Gilbert to Crittenden, N. Y., correlated by Leverett with the Lockport moraine.*

This and later American stages, all of minor importance and duration in comparison with the preceding, cannot probably be shown to be equivalent with Geikie's European divisions belonging in the same time. Successive American boundaries of the receding ice-sheet are noted as on Plate V, in accordance with studies of the Laurentian series of glacial lakes.

8. TORONTO STAGE. Slight glacial oscillations, with temperate climate nearly as now, at Toronto and Scarboro', Ont., indicated by interbedded deposits of till and fossiliferous stratified gravel, sand, and clay. These sections and the climatic conditions of the Toronto stage, with its place in the series, are more fully considered in the May number of the AMERICAN GEOLOGIST (pages 285-291).

Although the waning ice-sheet still occupied a vast area on the northeast, and twice re-advanced, with deposition of much till, during the formation of the Scarboro' fossiliferous drift series, the climate then, determined by the Champlain low altitude of the land, by the proximity of the large glacial lake Algonquin, succeeding the larger lake Warren, and by the eastward and northeastward surface atmospheric currents and courses of all storms, was not less mild than now. The trees

*Am. Jour. Sci., III, vol. L, pp. 1-20, with map, July, 1895.

whose wood is found in the interglacial Toronto beds now have their most northern limits in the same region.*

9. IROQUOIS STAGE. Full expansion of the glacial lake Iroquois in the basin of the present lake Ontario and northward, then outflowing at Rome, N. Y., to the Mohawk and Hudson rivers. Gradual re-elevation of the Rome outlet from the Champlain subsidence had lifted the surface of lake Iroquois in its western part from near the present lake level at Toronto to a hight there of about 200 feet, finally holding this hight during many years, with the formation of the well developed Iroquois beach.

Between the times of lakes Warren and Iroquois, the glacial lake Lundy, marked by the beach ridge of Lundy's Lane,† probably had an outlet east to the Hudson by overflow across the slope of the highlands south of the Mohawk; but its relationship to the glacial lake Newberry, named by Fairchild as outflowing to the Susquehanna by the pass south of Seneca lake,‡ needs to be more definitely ascertained.

10. ST. LAWRENCE STAGE. The final stage in the departure of the ice-sheet which we are able to determine from the history of the Laurentian lakes and St. Lawrence valley is approximately delineated on Plate V, when the glacial lake St. Lawrence, outflowing through the Champlain basin to the Hudson, stretched from a strait originally 150 feet deep over the Thousand Islands, at the mouth of lake Ontario, and from the vicinity of Pembroke on the Ottawa river, easterly to Quebec or beyond. As soon as the ice barrier was melted through, the sea entered these depressed St. Lawrence, Champlain, and Ottawa valleys; and subsequent epeirogenic uplifting has raised them to their present slight altitude above the sea level.

Later stages of the glacial recession are doubtless recognizable by moraines and other evidences, the North American ice-sheet becoming at last, as it probably also had been in its beginnings, divided into three parts, one upon Labrador, an-

*AM. GEOLOGIST, as cited; also Dr. George M. Dawson's letter in the July number, pp. 65, 66.

†J. W. Spencer, Am. Jour. Sci., III, vol. XLVII, pp. 207-211, with map, March, 1894.

‡Bulletin, Geol. Soc. of America, vol. VI, pp. 353-374, with map and five plates from photographs of topographic features, April, 1895.

other northwest of Hudson bay, as shown by Tyrrell's observations,* and a third upon the northern part of British Columbia. From my studies of the glacial lake Agassiz, whose duration was probably only about 1,000 years, the whole Champlain epoch of land depression, the departure of the ice-sheet because of the warm climate so restored, and most of the re-elevation of the unburdened lands, appear to have required only a few (perhaps four or five) thousand years, ending about five thousand years ago. These late divisions of the Glacial period were far shorter than its Kansan, Aftonian, and Iowan stages; and the ratio of the Glacial and Champlain epochs may have been approximately as ten to one. The term Champlain conveniently designates the short closing part of the Ice age, when the land depression caused rapid though wavering retreat of the ice border, with the accumulation of many retreatal moraines of very knolly and bowldery drift.

How the Ice-sheet formed Marginal Moraines.

One difficulty which will arise in the minds of many glacialists, concerning the brevity of the time allotted to the Wisconsin and later moraine-forming stages should receive special consideration. The view here presented, with the light derived from my work on lake Agassiz, implies that the conspicuous belts of morainic hillocks, hills, and ridges, consisting of very bowldery till, frequently with much kame gravel and sand, of which I have mapped twelve in Minnesota and North Dakota, and Leverett a still larger number in Illinois, Indiana, and Ohio, were each amassed within a few years, or at the longest probably no more than 25 or 50 years, even for the accumulation of the prominent Leaf hills, rising 200 to 350 feet above the surrounding country. How could such rapid drift transportation and deposition take place? If this question can be satisfactorily answered, with reference of the moraines both in North America and in Europe to the time of retreat from the Iowan glacial boundaries, a chief argument, which is much relied on by the defenders of the theory of two or several distinct glacial epochs, having unlike methods of drift accumulation, will be set aside.

*Geol. Magazine, IV, vol. I, pp. 394-399, with map, Sept., 1894: Am. Geologist, vol. XIV, pp. 338-340, Nov., 1894.

As an aid for clearer statement, the accompanying figure, drawn on the same scale vertically as horizontally, may represent a section of the border of the departing ice-sheet along a distance of ten miles from south to north, where its original thickness, as probably for the vicinity of the Leaf hills, in northwestern Minnesota, was about a mile. Englacial drift, as I have shown in previous papers,* had been carried by the ice currents in some important amount into the basal quarter or third of the ice-sheet; and when the superficial melting or ablation reduced the ice border to a less thickness, this drift was gradually uncovered upon the ice surface. The rates of ascent of the frontal slope are taken in accordance with the upper limits of glacial action on mountains, and after careful consideration of the surface gradients of the Alpine glaciers and of the Greenland ice-sheet, as 400 feet in the first mile, 200 feet in the second mile, and 150, 120, 100, 85, 75, 67, 60, and 55 feet in the third to the tenth miles, respectively, attaining an altitude of 1,312 feet, or about a quarter of a mile. Thence we may suppose the ascent to average 50 feet per mile for the next nine miles, by which the altitude of a third of a mile, the probable upper limit of the englacial drift, would be reached.

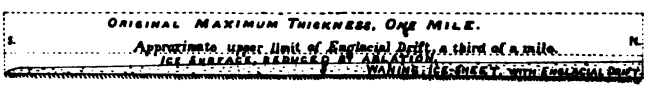


FIG. 1. Section of the border of the ice-sheet during its retreat. Scale, three miles to an inch.

On areas where the ice-sheet built up large marginal moraines, and also wherever its drainage from ablation brought exceptional volumes of modified drift, or stratified gravel, sand and clay, directly supplied by the ice melting, we must believe that the amount of the englacial drift was greater than on other tracts having smaller moraines and little modified drift. Let us assume, therefore, for the definite illustrative case in which we are seeking to account for prominent moraine accumulations, that the total englacial drift, in the lower third or 1,760 feet of the ice-sheet, was equal to a thickness of 15 feet. This may have been distributed, as shown in the ac-

*Bulletin, G. S. A., vol. III, 1892, pp. 134-148: vol. V, 1894, pp. 71-86. AM. GEOLOGIST, vol. VIII, pp. 376-385, Dec., 1891; vol. X, pp. 339-362, Dec., 1892: vol. XII, pp. 36-43, July, 1893.

companying table, so that the basal ice stratum, 400 feet thick, terminating within the first mile from the front, should contain 5 feet of englacial drift; the stratum, 200 feet thick, terminating in the second mile, 2 feet of drift; the 150 feet of ice terminating in the third mile, 1½ feet of drift; the fourth mile's ice stratum, 120 feet thick, 1 foot of drift; and the stratum of 100 feet in the fifth mile, seven-tenths of a foot. The amount of englacial drift above the altitude of 970 feet, reached at the end of five miles, would be about five feet in a thickness of about 800 feet of ice, the upper limit, as before noted, being assumed to be 1,760 feet above the land surface.

The rate of ablation of the ice in the warm summers of the Champlain epoch, with alternating sunshine and still more efficient rains, probably averaged from two to four inches daily during 200 days of the warm portion of each year. In the remaining five and a half months we may suppose that the snowfall and ablation counterbalanced each other, while the ice advance, though diminished on account of the lower temperature, would produce some thickening of the border, When a series of years had a small mean rate of ablation, the ice front remained nearly stationary, giving the conditions necessary for the formation of a marginal moraine; but when the ablation was more rapid, no belt was occupied by the front so long as to be marked by morainic hills and ridges. An average ablation of two inches per day during 200 days of each year may be assumed as permitting the front to remain on the same line, or with advances and recessions not exceeding a half mile or one mile from that line. The resulting moraine would be heaped irregularly on a belt one or two miles wide.

Conditions of Morainic Drift Accumulation.

Ice stratum terminating in successive miles	ASCENT OF ICE SURFACE			GLACIAL ADVANCE.		MORAINIC DRIFT, IN FEET.		
	Feet per Mile.	Total.	Ratio.	Feet daily in summ'r	Miles in 30 years.	Englacial.	Becoming superglacial in 30 years.	Previously superglacial.
1	400	400	1:13	2.1	2.5	5.0	12.3	10.9
2	200	600	1:26	4.3	5.3	2.0	10.6	8.0
3	150	750	1:35	5.8	6.7	1.5	10.0	6.5
4	120	870	1:44	7.3	8.7	1.0	8.7	5.5
5	100	970	1:53	8.8	10.4	0.7	7.3	4.8
Total average thickness of moraine from these five miles, 83.7 feet, if amassed on a belt one mile wide.							48.9	34.8

To supply the ice by onflow equivalent to the ablation of two inches daily in summer upon the first mile from the fron-

tal line would require an average forward current of 26 inches daily for the lowest 400 feet of the ice-sheet. On the land bed, where it was impeded by friction, the rate was very small, thence gradually increasing upward. In the second mile the ice would retain its hight unchanged under this ablation by an average onflow of 4.3 feet daily for the stratum of ice 200 feet thick terminating in that mile; the third mile would require for its stratum of 150 feet a daily current of 5.8 feet; and the fourth and fifth miles would require currents, respectively of 7.3 and 8.8 feet. Between nine and ten miles from the ice front, at an altitude of 1,257 to 1,312 feet, the ablation could be offset only by a current of 16 feet daily. By such currents, urged forward by the great weight of the more central and increasingly thicker part of the ice-sheet, the superficial wasting of the ice border would be evenly balanced, holding, therefore, the nearly steady frontal line indispensable for abundant marginal drift deposition. The gradients thus assumed for the ice surface near its boundary are probably twice as steep as they were during the earlier stages of predominant ice accumulation. Hence, with the greatly increased Champlain temperature, the rates of glacial movement were perhaps five or even ten times faster than during the maximum stage of glaciation.

If the outermost five miles of the ice, having the conditions here assumed, remained in essentially unchanged position thirty years, the total volume of drift there becoming superglacial would be equivalent to about 50 feet on a width of one mile. With the previously superglacial drift of the same outer belt of the ice, which, like the foregoing, must have been carried forward to the boundary, there would be a thickness of about 85 feet; and with all received in the same time from the more distant part of the ice surface, up to ten miles from the margin, the total terminal mass of drift would equal at least an average of 100 feet on a belt one mile wide. This amount, amassed by the small frontal oscillations of the ice so as to form irregularly grouped hills and ridges, separated, as those of the moraines usually are, by deep and wide hollows, would constitute a morainic belt probably unsurpassed either in North America or Europe. Under the same conditions, a small but distinct moraine might be formed in only five or

ten years; or, where the ice-sheet had less englacial drift, as a quarter or only a tenth as much, the smaller parts of a moraine belt would be made during the same thirty years in which elsewhere its most prominent portions were being deposited.

Comparison of Alaska and Greenland.

The Malaspina ice-sheet in Alaska, reaching from the St. Elias range to the ocean, has been slowly retreating, like the Muir glacier and others of that country, during the past hundred years or probably much longer. On all its border for a width of a few miles, now thinned perhaps to a quarter part, or less, of the earlier depth, the waning ice is covered by its formerly englacial drift; but, in that cold climate, the glacial movement is so very slow that forest trees, with luxuriant undergrowth of shrubs, and many herbaceous flowering plants, grow on this drift lying upon hundreds of feet of ice as revealed by stream channels. Advancing toward the interior, the explorer soon comes upon higher clear ice and névé, having risen above the plane of the englacial débris, excepting along the course of belts of medial surface morainic drift, swept outward from spurs of the mountains. This ice-sheet partially suggests the conditions of the moraine-forming southern porthern of the North American and European ice-sheets during the Champlain epoch; but these had a climate much warmer than that of Alaska, with consequent far more rapid ablation and stronger glacial currents.

In Greenland, on the other hand, the mean temperature has probably been gradually lowered during several centuries past, since the prosperous times of the Norse colonies 900 to 500 years ago. A great ice-sheet, 1,500 miles long with a maximum width of 700 miles, covers all the interior of Greenland; and, although now its extent is less than during the Glacial period, it has doubtless held its own or mainly somewhat increased during several hundred years. While the snow and ice accumulation is predominant, no englacial drift becomes superglacial; but in the region of Inglefield gulf Chamberlin finds the frontal ice-cliffs well charged with englacial débris to a third or half of the total hights of 100 to 200 feet or more. The same ratio of the lower part of the ice-sheet containing drift would quite certainly give it a thickness of 1,000 to 2,000

feet in the deeply ice-covered central portion of Greenland. Other features especially noted are the very distinct stratification of the ice and its differential forward motion, producing not only this stratification but also sigmoid folds and overthrust faults, where the upper layers move faster than the lower and these in turn faster than the friction-hindered base. In just the same way, as I have shown in the foregoing pages, the accelerated currents of the waning ice-sheet during the temperate Champlain epoch overrode each other in succession from the highest to the lowest on the moraine forming border, bearing a great amount of superglacial drift to the margin. If a mild temperate climate could bring to Greenland the conditions of the Champlain epoch, its thick ice-sheet in the interior under rapid ablation would fully illustrate, as the Malaspina glacier even now does in a considerable degree, the formation of the great series of morainic drift hills which mark stages in the retreat of the continental ice-sheets.

Marginal Moraines chiefly a Characteristic of the Champlain Epoch.

From this discussion of the origin of marginal moraines, it will be seen that their accumulation belonged chiefly to the Champlain epoch of land depression, restored warmth, and mainly rapid glacial retreat, interrupted by times when the ice-sheet for several years or decades of years held a nearly stationary position. According to the supposition that two inches of daily summer ablation was approximately equalled by the glacial onflow, whenever the ablation was at a faster average rate, as three or four inches daily, the ice receded, depositing the smoother till sheets between the hilly marginal moraine belts.

During the stages of ice accumulation, up to the maximum of the glaciation and to the Iowan stage, I think that the ice-sheet eroded much drift on its central area and bore it forward in the basal quarter or third of the whole thickness of the ice, depositing much of it, however, as subglacial till within fifty miles, more or less, back from its front. When the final recession of the ice carried its border gradually backward over all its area, I believe that the process of subglacial drift deposition continued, forming the ground moraine or lower part of the till progressively as the ice border withdrew.

So much of the drift as remained englacial when the frontal line in its retreat reached the place of a temporary pause, permitting a marginal moraine to be formed, was then borne forward in the manner described to the boundary.

Only with a rate of ablation much faster and with glacial currents much stronger than those of the Arctic regions or of the continental ice-sheets during their time of accumulation under the severe climate of their high plateau elevation, in short, only during the Champlain epoch, when the land had sunk from its preglacial and Glacial altitude both in America and Europe, could noteworthy peripheral moraines be amassed. They record on each continent the definite closing epoch of the Glacial period.

EDITORIAL COMMENT.

Dæmonelix or What?

In the midst of the controversy which has arisen over this strange Nebraskan fossil may we remark that the correct spelling of the name adopted is *Dæmonhelix*. It may perhaps be regretted that a more euphonious form, such as *Helicodæmon*, was not employed from the first, but this not being the case the correct spelling of the term may as well be used.

E. W. C.

Reconnoissance Map of the United States.

In the July number of the American Geologist we published a review of a "Reconnoissance map of the United States" by Mr. W J McGee. From a recent letter from Mr. McGee, concerning this review, we quote as follows: "The review contains several minor errors, which may mislead readers not familiar with the history of geologic mapping, and will certainly lead to disappointment on the part of the many geologists who will receive the Fourteenth Annual Report of the United States Geological Survey but will not receive the series of maps referred to in the notice. The first paragraph of this review should have read about as follows:

"Reconnoissance map of the United States showing the distribution of the Geologic Systems so far as known * * * by W J McGee, 1893.—This map forms plate II of the Fourteenth Annual report of the United States Geological Survey (for 1892-'93). The scale is about 115 miles to an inch, be-

ing printed on the base used for the geologic map compiled by the same author in 1884, and published in the Fifth Annual Report of the Survey; this earlier map serving also as the basis of Professor Hitchcock's map of 1886, which was printed (by permission of director Powell) from the stones prepared for the survey edition, with certain alterations—notably the extension of reconnoissance and hypothetic coloring over unsurveyed portions of the country. The present map, like its predecessor, omits coloring from Canada and Mexico, and from areas not yet surveyed geologically; but it differs from its predecessor in that the results of trustworthy reconnoissance in the unsurveyed portions of the United States are introduced. In addition to the regular edition of this map accompanying the Fourteenth Annual Report of the Survey, a limited number of copies of the complete map and of a series of sheets each showing a single geologic system have been printed by director Walcott for the use of working geologists. A number of sets of maps, each comprising the geologic map, the base map with contours but without geologic colors, and a series of the system sheets, has been distributed by the Survey in advance of the issue of the report." U. S. G.

Beginning with this month's issue the AMERICAN GEOLOGIST will be printed by the Franklin Printing Co., 50 Fourth St. S., Minneapolis. Mr. Nelson F. Twing, under whose careful oversight this journal has been printed for the last five years, is manager of this company. The rates for excerpts, found on the third page of the cover, have in some cases been slightly reduced.' U. S. G.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Evolution of Australia. By A. C. GREGORY. At the recent meeting of the Australian Association for the Advancement of Science the president, the Hon. A. C. Gregory, C. M. G., chose for the subject of his address "The Geographical Development of the Australian Continent." Mr. Gregory's great experience as an explorer lent unusual interest and value to his statements.

In very early times a chain of islands extended northward from Tasmania to cape York, a distance of 2,000 miles, with a breadth of not more than one hundred. In western Australia a wide table land stretched from cape Leeuwin northward for 1,000 miles. Both were

granitic. Between them lay a deep sea dotted perhaps with a few islands. The waste of these ancient rocks was deposited in the adjacent sea forming the Cambrian, Silurian and Devonian series, the last of which is in some places 10,000 feet in thickness. The later part of the ensuing Carboniferous era was marked by an elevation of several thousand feet and a severe crumpling of the strata "by a force from the east," which together brought most of the former shores and sea bottoms of the eastern land high above the water. This was apparently the date of the deposition of the now auriferous fissures. The result seems to have been a continent much like that now existing, with an elevated range along the eastern coast and a climate favorable to vegetation.

Later, about the beginning of Mesozoic time, a second elevation took place, carrying the continent yet higher and annexing the Great Barrier reef, New Guinea and possibly Timor, but making little change on the western side. To this elevation and the high mountains which it developed along the eastern coast, probably 10,000 feet in altitude, Mr. Gregory is inclined to attribute the great moisture of the Carboniferous era, whose deposits are limited entirely to that part of the continent. An extensive depression ensued in late Mesozoic time, carrying the interior part again below the sea and affording room for the wide-spread Cretaceous rocks. Only the higher peaks and ranges rose above the water.

Subsequent elevation, without distortion, raised the whole area to a hight about 500 feet above its present level and it then presented almost its present appearance. Extensive river systems then existed in the interior and violent volcanic outbursts poured basalt over the new Cretaceous beds. Then followed the era of the great Australian marsupial fauna when *Diprotodon*, *Nototherium* and others obtained subsistence where now the kangaroo cannot live. Great rainfall marked this era, as is shown by the way in which the fossils are buried on the margins of extinct freshwater lakes.

But desiccation followed and the huge marsupials vanished, the dingo alone surviving by adaptation to the altered conditions, and the interior became the dry and waterless area that it is at the present time.

E. W. C.

Portland Cement: a Monograph. By CHARLES D. JAMESON. (The Transit, vol. III, no 1, 192 pp. Iowa City, 1895.) The recent broadening of the scope of geological surveys so that the official geologist is expected now to not only point out the location of valuable beds but to also indicate the best methods of working them, makes it imperative that he keep informed upon certain portions, at least, of technical literature. Few recent contributions are therefore more welcome than that which Prof. Jameson has just made to the study of cements. There has been of recent years a notable expansion in the business of cement manufacture. Portland cement was first manufactured in 1824 in England. The industry for many years made little headway against the active competition of the natural or Roman cements. In 1852 the in-

dustry was introduced in Germany. Up to 1875 all the Portland cement used in this country was imported principally from Germany and England. There are now factories at Bellefountaine, Ohio; South Bend, Indiana; Warner's, New York; and Yankton, S. D. In 1889 there were only 150,000 barrels of cement manufactured here and 650,000 imported, so that there would seem to be abundant room for more factories.

Prof. Jameson's monograph is the outgrowth of his lectures before the engineering students at the State University of Iowa. While the subject is Portland cements, the author gives considerable information regarding cements and limes of all kinds. It is noteworthy that, whereas Gilmore's work, the last preceding general treatise on cements from the American standpoint, is so largely taken up with descriptions of the Roman cements and Portlands are only incidentally discussed, in the present volume the relations are transposed.

The work includes studies on the manufacture, testing and use of the cement. In connection with the latter are some beautiful illustrations of monolithic construction as employed in the dams of the Hennepin canal and the museum of Stanford University. The economy with which the vast chalk beds of the interior may be utilized and the excellent character of the product is insisted upon. The monograph is exceedingly valuable to all working in economic geology, since it places in convenient form a vast quantity of matter which was before scattered, principally in French and German works, and was well nigh inaccessible. In addition much new matter of great value is given. H. F. B.

Origin and Use of Natural Gas at Manitou, Colorado. By WILLIAM STRIEBLY. (Colorado College Studies, Fifth Ann. Pub., pp. 14-35. Colorado Springs, 1894.) In considering the origin of the gas-charged mineral water at Manitou the author gives a brief resume of the geologic features of the region. It is pointed out that the springs are located on the crests of low folds in the sedimentary strata near the contact of these beds with the Archean granites. Attention is called to the presence of a prominent fault at the exact contact and of a series of smaller parallel slips. The study of a number of chemical analyses allows several interesting inferences to be drawn, among which are the following:

1. All the springs hold the same salts in solution, a fact which seems to point to a common origin.

2. The waters of the Navajo and Manitou springs are almost identical in mineral contents, while the Ute Iron spring contains a much smaller quantity of dissolved salts. It is very probable that percolating waters from the streams or from local seepage channels make their way into the springs such influx being greater in some springs and smaller in others. In the Ute Iron spring calcium and magnesium are low, and silica, chlorine, iron, sulphuric-anhydride, soda and potash relatively high. The proximity of this spring to the silicate rocks on the south, and to the very broken siliceous Silurian limestone and Cambrian quartzites on the north and west, suggests reasons for a possible change

in this spring water, on the supposition that its main source is the same as that yielding the waters of the other groups.

3. The presence of so large quantities of the bicarbonates of calcium and magnesium points to a prolonged contact of the waters with the limestones.

4. The almost total absence of iron salts indicates either a source quite free from ferruginous minerals, or more probably the oxidation of dissolved iron and its previous precipitation.

5. The high percentage of chlorides may be derived from the Silurian rocks or with less probability from the more distant Jura-Triassic beds.

6. The large percentage of sodium bicarbonate probably indicates an origin among silicate rocks, whence the soda (and potash) may come as carbonates formed by the decomposition of the rocks by atmospheric waters containing carbonic acid, or as alkaline silicates, which react upon the limestones (calcium carbonate) before reaching the surface.

7. The sulphates may come from unseen gypsum beds, but it is probable that they come in greater part, at least, from the oxidation of sulphides in granites, igneous rocks, or even sedimentary beds.

8. The concentration of the solutions—that is, the large quantity of mineral matters contained in the springs' waters, comes evidently from prolonged contact with rocks, such as would arise from percolation and probably also from an increased solvent power of the water, due to heat or pressure, or both combined.

9. The difference in temperature of the several springs is remarkable as showing that either the waters come from different sources, or if coming from the same source have been cooled in an unequal degree by passing through diverse strata, or through the influx of cooler foreign waters.

10. The variation of the springs between summer and winter, in their contents of mineral matters dissolved, in the quantity of water flowing from them and in the volume of gas yielded, together with the remarkable uniformity of temperature throughout the year in some of them, are evidently significant phenomena.

The gas with which the water is charged is carbon-dioxide and the author reviews the various explanations usually offered for its origin. It is believed that in this instance the gas is derived from the chemical decomposition of limestone by acid waters or salts. The theory advanced for the origin of the natural gas at Manitou is thus summarized: "Water percolating through silicate rocks and becoming highly mineralized under favorable conditions of temperature and pressure, makes its way through cracks and profound rock-fissures by the action of gravity and the ascensional power imparted by heat, to the limestones west and north of Manitou. It is here increased in volume and in dissolved salts by the numerous additions of seepage waters from the local rocks, and also lowered in temperature at the points where these influxes occur. By chemical reactions some of the dissolved salts are changed, and the carbon-dioxide originally held (almost entirely) by the limestones is liberated from that combination but dissolved in the water

on account of the great hydrostatic pressure. As the waters rise through the irregular channels enlarged from cracks and seams, the pressure decreases and more and more of the dissolved gas escapes from the water until at last, when the surface is reached at the various springs, the gas emerges with the rythmic flow due to the irregularities in the channels of exit." H. F. B.

Lead and Zinc Deposits of Missouri. By ARTHUR WINSLOW, assisted by JAMES D. ROBERTSON. (Missouri Geol. Survey, C. R. Keyes, State Geologist; vols. 6 and 7, 763 pages, 40 pls., 3 folded maps; JeffersonCity, 1895.) As gleaned from the preface, the investigation was begun, first, in connection with the U. S. Geological Survey, and later independently. During the past year the extent of the report has more than doubled over the estimate first made, probably due to the fact that since the authors' relief from the administrative work of the survey they have been able to devote all their time to the preparation of the report.

The report has been divided into three parts. The first portion contains an historical sketch of the metals and a summary of what is known of them in all countries of the globe. Particular attention is given to the lead and zinc producing districts of North America with which the Missouri product is brought into competition. A chapter is also devoted to the metallurgy of the metals, and the various processes are described with sufficient minuteness for all practical purposes. Concise tables of the production in the United States are also given in this connection, together with the prices.

The second section outlines the history of mining in Missouri, and the general geology of the southern half of the state. The development of the mining in the state is traced from the time of the earliest explorations. The physical characters of the lead and zinc regions are described at length. The geological formations containing the metals under consideration are referred to in a general way, and considerable detail entered into in the case of the most important localities. The lithological differences are compared and some of the salient structural features pointed out. Under ore deposits is a full consideration of the distribution, the form, structure and composition of the ore bodies, their manner of formation and the origin of metalliferous veins. Concerning the latter topic, the various theories are set forth and their application to Missouri deposits clearly given. Smelting and manfacturing received the attention they demand, and full statistics are given regarding the production of the two metals in Missouri, the prices received from year to year and the total output of the various counties.

The third part is an account of the Missouri mines, with a systematic and detailed description of the important developments and occurrences of lead and zinc. Three districts are recognized, the southeastern, the central and the southwestern. Here is incorporated all the detailed information concerning the various camps. Many of these are mapped and the workings of typical individual mines plotted. This is the por-

tion of the work which will appeal most directly to the people actually engaged in working in the diggings.

A considerable part of the report is devoted to a description of the general topographic and geologic features of the state. So much detail may seem unnecessary; Mr. Winslow states that "The writer has endeavored to embody, and thus to place on record, all the notes of importance relating to the geology of the southern part of the state, which he accumulated during his occupancy of the position of state geologist and which the recent severance might prevent the publication of." Mr. Robertson has already published in the AMERICAN GEOLOGIST (vol. XV, pp. 235-248, April, 1895,) a comprehensive abstract of this report on the lead and zinc deposits of Missouri.

"A Study of the Cherts of Missouri," by DR. E. O. HOVEY, is embraced in the appendix. The two volumes in size and general appearance are similar to the other excellent reports of the Missouri Survey.

U. S. G.

On Some Dykes Containing Huronite. By ALFRED E. BARLOW. (Ottawa Naturalist, vol. IX, no. 2, pp. 25-47, 1895.) In this paper, read before the Geological Society of America at the Baltimore meeting, there is a full description of the known occurrences of this mineral. Huronite was described by Thompson in 1835 as a mineral species from material obtained from a diabase boulder on Drummond island, lake Huron. The exact relationship of this mineral has been open to some doubt. Dana originally placed it under prehnite and later mentions it as a supposed altered form of iolite. T. Sterry Hunt considered it "an impure anorthite-like feldspar related to bytownite," and on the same authority Dana speaks of it as "an altered mineral near fahlunite." In 1885 Dr. B. J. Harrington examined the mineral, using material from Pogamasing, and upon this authority it is in Dana's last edition placed under anorthite. Michel Lévy and Lacroix considered it a decomposition product of iolite or cordierite.

For some time after the original description of the mineral it was not known from material found in situ. Knowledge on the subject has been accumulating until in the present paper it is described from eleven localities. The doubt as to the correct position of the mineral arose from the fact that its true nature could not be discovered by analysis. Mr. Barlow studied the material with the microscope and discovered "that in every case the so-called huronite is really a plagioclase near the basic end of the series which has undergone more or less complete saussuritization."

In the present paper the results of this detailed petrographic study of material from the different localities are given and the different stages in the alteration are traced. H. F. B.

On Lawsonite, a New Rock-forming Mineral from the Tiburon Peninsula, Marin Co., Cal. By F. LESLIE RANSOME. (Bull. Dept. Geol. Univ. Cal., vol. 1, no. 10, pp. 301-312. pl. 17, May, 1895.) This is a clear and colorless or gray-blue mineral which occurs as an important rock-

making constituent of a rather massive outcrop of crystalline schist. The associated minerals are margarite, in which the new mineral is frequently imbedded, epidote, actinolite, glaucophane and red garnet. Lawsonite is orthorhombic in crystallization, and its axial ratio is *a:b:c* = .9852 : 1 : .7385. It possesses two fairly distinct habits, the crystals occurring in cavities show a strong development of the prismatic faces, while those imbedded in the margarite are usually larger and have a prevailingly tabular habit, the basal plane being well developed. A perfect cleavage exists parallel with the brachypinacoid and a sub-perfect cleavage parallel with the base, while an imperfect prismatic cleavage can sometimes be seen in thin sections. In optical character the mineral is positive and the axial plane is the brachypinacoid. In certain basal sections pleocroism is strong, but in sections of the ordinary thickness it is rarely detected. In thin sections of the schist the bright polarization colors and high relief of the mineral are decidedly striking. The specific gravity is about 3.085, and the hardness is 8. The chemical formula deduced from two analyses is $H_4 CaAl_2 Si_2 O_{10}$, being similar to carpholite ($H_4 MnAl_2 Si_2 O_{10}$). The possibility of the isomorphism of the two minerals is suggested. Lawsonite is named in honor of Prof. Andrew C. Lawson of the University of California. U. S. G.

Post-Laramie Deposits of Colorado. In the volume recently issued by the Colorado Scientific Society* there are several papers† which add to our knowledge of this interesting series of beds. It will be remembered that in 1888 Eldridge and Cross‡ described the Arapahoe and Denver formations as post-Laramie. At the same time Cannon§ announced the discovery of Tertiary Dinosauria in the Denver beds and Hills¶ shortly after described Tertiary beds from the Huerfano River basin considering them as Eocene but recognizing their probable contemporaneity, in part at least, with the Denver and associated beds. In 1889** he gave additional notes on the Huerfano beds. In 1890 Cannon†† noticed the description by Marsh‡‡ of the dinosaurian remains found at Denver and similar remains from Montana, and in the same year Hills§§ discussed the beds already described and added considerable information regarding contemporaneous deposits. The original paper by Cross was revised and republished in the American Journal of Science¶¶ and more recently he has described*** the whole subject of the post-Laramie.

The post-Laramie beds are not confined to Colorado but similar deposits have been noted by Canadian geologists and Weed††† has recent-

*Proc. Col. Sci. Soc., IV, 1891, 1892, 1893.
†Remarks on the Classification of the Huerfano Eocene; by R. C. Hills; pp. 7-9.
The Post-Laramie Beds of Middle Park, Colorado; by Whitman Cross; pp. 192-214.
Geology of Denver and Vicinity; by Geo. L. Cannon, Jr.; pp. 224-234.
‡Proc. Col. Sci. Soc., III, i, 86-118, 119-133.
§Ibid., 140-147.
Ibid., 148-164.
¶Ibid., III, i, 217-223.
**Ibid., III, iii, 253-254.
††Am. Jour. Sci., (3), XXXIX, 81-86, Jan., 1890.
‡‡Proc. Col. Sci. Soc., III, iii, 388-397.
§§Am. Jour. Sci., (3), XXIX, 261-282, 1889.
¶¶Ibid., XLIV, 19-42, 1892.
***Bull. U. S. Geol. Surv., No. 105.

ly described the Livingstone formation as belonging to the same series.

The present paper by Hills is mainly a rectification of the nomenclature. He would now arrange the Huerfano deposits as follows:

Huerfano Series (Eocene)	Huerfano beds=Bridger Group.	
	Couchara beds	(Lower Eocene)
	Poison Canyon beds	

He considers the Couchara and Poison Canyon beds as the equivalent of all the Rocky Mountain Eocene older than the Bridger, including the Green River and Wasatch and probably a still older series whose deposition immediately followed the post-Laramie disturbances. In the latter category are placed the Arapahoe and Denver beds, similar beds near Canyon City, the Ruby beds, and certain beds in the South park and on the Yampa.

In the paper by Cross the post-Laramie of Middle park is discussed in detail. These beds had been previously studied by Hayden, Marvin, and White, all of whom agreed in placing them in the "Lignite" or Laramie. The determination of their position rests in the main upon Marvin's notes and seems to have been based upon the general stratigraphic position, a supposed lithological resemblance and the testimony of certain plant remains, as well, probably, as the absence of any strong evidence allying them with any other beds. In an examination of the outcrops Cross finds that all the lithological characters which so distinctly mark the Denver beds are equally well shown in the Middle Park beds. The "doleritic breccia" described by Marvin as underlying them is shown by Cross to grade up by transition beds into the supposed "Lignitic." It is made up of a large series of andesitic rocks such as characterize the Denver beds at the type locality. Certain of the strata contain the same reddish heulandite cement which is also characteristic. The whole lithological character of the beds in fact is strikingly like the Denver beds and unlike the Laramie proper. Marvin noted an unconformity separating the beds in question from the underlying Cretaceous but was disposed to consider it as only of local importance. Cross shows the greater extent of the unconformity and correlates it with that which elsewhere succeeds the Laramie proper. The evidence from the plant remains cannot at the present time be fully discussed since the much needed revision of the Laramie fauna, undertaken by Mr. Knowlton, is not yet finished. Of the twenty-eight species found in the old and new collections from Middle park four being doubtful and three unknown elsewhere, at least twelve occur in the Denver beds as developed at Golden. The paleontological evidence would seem then to bear out that derived from lithological resemblance and unconformity in placing the Middle Park beds in the series which is at present known by the inadequate term post-Laramie.

In the course of a resumé of the geology of Denver and vicinity Cannon reviews the history of the discovery of vertebrate remains in the Denver beds. The interesting discussions which grew out of these discoveries and were terminated by the description by Marsh, from material collected by Hatcher in Wyoming, of that interesting order of horned Dinosauria known as Ceratopsia, are also brought to mind.

H. F. B.

Étude sur le Metamorphisme de contact des roches volcaniques. Par A. La Croix. (Mem. Acad. Sciences de l'Institut de France. Ex. de Tome xxxi, 1894.) The author confines himself to the consideration of volcanic rocks *per se*, not older than the Tertiary, which obviously leaves unstudied a large field of contact metamorphism. It conduces to clearness and probably to the correctness of his conclusions to embrace in the discussion only such phenomena as can be referred without doubt to the action of contacting volcanic rock, for many of the older volcanic rocks, and the sediments they modified, have undergone later modifications through the action of other forces, and these changes are liable to be confounded with those which are due to the volcanic contact.

The author considers separately the effect of basaltic and of trachytic rocks on other rocks in contact with or enclosed in them, giving a history of all researches on metamorphism and adding new results of his own. Among his conclusions are the following:

1. Heat alone is unable to produce the phenomena of intense metamorphism, but mineralizing waters under pressure have played an important rôle in metamorphic changes.

2. Volcanic rocks, either in outflow or in dikes, whatever the nature of the molten mass, produce identical effects upon the rocks with which they come in contact.

3. Basic volcanic rocks, when they entirely enclose foreign masses, through heat cause a slight chemical transformation in a narrow zone, by the intimate mixture of the modifying and the modified rocks: but trachytic eruptives produce chemical phenomena throughout their enclosures, the simple calorific phenomena seen in the basic eruptives being developed as chemical change through the action of caustic fluids under pressure and at a high temperature.

4. These chemical transformations, so far as studied, are all produced by the addition of elements to the rock modified; such as vapor of water, alkaline silicates, chlorides, and sometimes fluorides, all of which have borne important parts in the reactions which have taken place. The number of minerals that can be formed, for instance in a limestone, by these reagents are necessarily quite limited, from which fact it is easy to see how the chemical transformations in contact metamorphism are always the same whatever be the nature of the modifying eruptives.

5. In the case of enclosures of rock by eruptives, the greater chemical effect of the trachytic eruptives is probably due to their less fusibility, less conductivity of heat, greater porosity, through which they maintain their mineralizing agents longer and are enabled to produce on their enclosed masses more profound mineralogical changes.

6. The principal factor in contact metamorphism is not, therefore, so much the heat itself as the physical conditions in connection with which the heat operates. In one set of conditions (volcanic rocks) the mineralizing fluids are readily disengaged, and in another (intrusives) they act energetically under pressure. N. H. W.

Étude minéralogique de la lherzolite des Pyrénées et de ses phénomènes de contact. Par A. La Croix. (Extrait des Nouvelles Archives du

Muséum d'Histoire Naturelle, Paris. 3me Série, VI, pp. 209-308, avec 6 planches des caracteres microscopiques, quarto, 1894.) This publication results from Prof. La Croix' connection with the Geological Survey of France, in the prosecution of which he was intrusted with an examination of the eruptive and metamorphic rocks of the Pyrenees. While this embraces all that is known concerning the mineralogy of lherzolyte, another contribution devoted to its geological relations will appear at a later date in the bulletins of the geological survey. This work is divided into three parts, viz.:

1. Historical sketch and rapid review of the geographic distribution and the age of lherzolite and of the rocks which accompany it.
2. The mineralogical study of all these rocks.
3. Description of the metamorphic phenomena produced by its contact with the secondary rocks.

Lherzolyte is a yellowish green, rather coarse-grained hard rock, easily disintegrated by atmospheric agents, consisting of olivine, enstatite (bronzite), chromiferous diopside and a chromiferous spinel, picotite—an eruptive, basic rock which, in the Pyrenees, has always heretofore been considered of a later date than a certain white crystalline limestone, and thus later than the Lias, or even of the Neocomien. Observations, however, made by the author, prove it is older than this limestone, which contains fragments of it in a rounded form. It is later, however, than another limestone which it cuts which contains fossils of the middle Lias. The ease with which the rock separates into its separate constituent elements has contributed to the exactness and the completeness of the study of the crystalline and optic characters. The rock is sometimes porphyritic with large crystals of bronzite and of diopside, and it sometimes contains hornblende. It has been affected by mechanical action, resulting in a "mortar structure," and in a secondary pseudo-porphyritic appearance.

Among the secondary mineralogical changes the author mentions rubifaction, serpentinization and amphibolization. These are very characteristic at the outcrops, which take a dark, rusty color greatly in contrast with the surrounding white limestone. In this change olivine plays a leading part. It turns red, by absorbing an ochreous-yellow substance which finally replaces it entirely. This is then easily removed by rains and forms a yellowish mud. The cavities left by the removal of the olivine bring the other minerals into relief, and they undergo a slow loosening disintegration which serves to allow the extraction of each separately. In the interior of the rock, however, these minerals, on fresh fracture, can with difficulty be distinguished from each other without microscopic examination.

Serpentinization has in some places gone on on a large scale, but frequently is confined to fissures.

Amphibolization, in its simplest form, is uralitization, or a change from pyroxene. It also takes place in the bronzite. Hornblende in certain places is so common that the author describes and names the rock containing it, as a special variety of lherzolyte. It is interesting

to note that the author, while recognizing certain changes due to dynamic forces, does not consider that there is any relation of cause and effect between amphibolization and dynamic action in the cases he has studied.

In comparing this rock with similar rocks from other parts of the world, he mentions the pyroxenytes of North Carolina and Maryland, described by Dr. G. H. Williams in the AMERICAN GEOLOGIST (vol. VI, p. 38, 1890), and calls attention to the confusion that attends the use of that term; Coquand, Hunt, Kalkowsky, Dana, Zujovic and Doelter employed it in various senses, none of them the same as that assigned to it by Williams. This whole group of similar rocks is included by the author under the term *pyroxenolyte*, and they are considered as special forms of lherzolyte, appearing as dykes. The term websterlyte, given by Williams to a bronzityte belonging in this group, had already been used to designate a mineral, a hydrated sulphate of alumina, and, as remarked by the author, has to be rejected as a synonym.

One of the most interesting facts reported by the author is the development of zeolites in the metamorphic rocks at the contacts with these basic eruptives. The zeolites are chabazite, thomsonite, and christianite, rarely stilbite. He has before reported zeolites in granulytes, gneiss, Paleozoic schists, cipolins of the gneisses, in Jurassic limestones, in porphyrytes and in ophitic diabase, where they seem to have resulted from mineralized waters which do not necessarily proceed from any great depth. These phenomena are all in the Pyrenees mountains.

N. H. W.

Peary Auxiliary Expedition of 1894: Geology. By T. C. CHAMBERLIN. (Pages 29-56, with eight plates, forming Appendix A of the Bulletin of the Geographical Club of Philadelphia, No. 5, June, 1895.) This report, appended to a narrative of the expedition by its leader, Mr. Henry G. Bryant, gives in popular form a concise but comprehensive summary of the author's geological observations in Greenland, which are being more fully published in the Journal of Geology. Its plates are from photographs of the unglaciated Dalrymple island, of the glaciated Carey islands, which have striæ and drift boulders on their summits, 500 feet above the sea, of the Bryant, Gable, Bowdoin, Fan, Tuktoo, and East glaciers, and of a portion of the edge of the ice-cap, being the same series which appears also in the author's presidential address to the Geological Society (Bulletin, G. S. A., vol. VI, pp. 199-220, Feb., 1895; AM. GEOLOGIST, vol. XV, pp. 197, 198, March, 1895). The greater part of the present paper treats, like that address, of the glaciers, local névé fields, and margin of the inland ice-sheet, in the vicinity of Inglefield gulf. It also describes the topography of the western coast, the general geology of the borders of Inglefield gulf, and the icebergs, floes, and pack ice of the region. Brief outlines of these minor parts may be here noted, supplementing the previous abstract cited in our March number.

From cape Desolation, near the south end of Greenland, northward for about half the distance to Disco island, the coastal mountains have sharply angular forms; but along the further extent to this large island

and the contiguous Nurgsuak peninsula, the high coast has mostly rounded crests and gently curving slopes, the contour having been smoothed by glacial erosion. "From Svarten Huk to the Devil's Thumb, north of Upernavik, a portion of the contours are serrate, while other parts are subdued. There is no marked predominence of either class. The coast of Melville bay is largely formed by the edge of the inland ice, which here comes down to the sea. The remainder is formed by promontories jutting out from the ice-sheet like dormer windows, or by peaks projecting like islands through the great sheet of ice. The Devil's Thumb and Melville Monument are rather slender rock columns, standing but a few miles off the border of the present inland ice-sheet. From cape York northward to Inglefield gulf, subdued contours prevail over rugged ones; the latter, however, are not entirely absent on the immediate line of the coast."

The mountainous border of Greenland terminates northward at Melville bay. Thence the border tract is a plateau with an average altitude of about 2,000 feet, upon which the inland ice deploys as it would on any lower plain, excepting where its glaciers descend in valleys from the summit toward the sea level. About half of the glaciers reach the sea, while the other half end on the land. The plateau may be the edge of a very extensive and elevated plain underlying the greater part of the ice-sheet. A lower and comparatively narrow peneplain is also sometimes observable, notably in the vicinity of Godthaab, descending gently to Baffin bay, in which its low undulations form numerous small islands.

Professor Chamberlin traces the following stages in the development of the grand topographic features of Greenland. "The upper plateau appears to signify that at some former period, not very remote geologically, yet certainly not very recent, the west coast of Greenland stood some 2,000 feet lower than at present, and remained in that position during a period sufficiently long for the reduction of considerable tracts to a gradation plane, but apparently not long enough for the reduction of all the surface, for the bordering mountains of southern Greenland appear to be survivals. After this partial leveling of the island, it appears to have been elevated to an altitude not very different from the present, and to have stood there long enough for the development of the coastal plain above described. Contemporaneously with this, the valleys doubtless extended themselves backward into the higher country. Later, a further elevation appears to have ensued to the extent of two or three thousand feet, during which the valleys were deepened and both the higher and lower plains considerably dissected upon their borders. Subsequent to this, the land sank to its present position, about which it is now obviously fluctuating, for there are evidences—among which are raised beaches and elevated shell deposits—that it has recently been elevated, and there are also evidences—among which are sunken ruins and forced migrations—that it has recently been sinking."

In the region of Inglefield gulf, the probably Archean crystalline rocks which form the principal mass of Greenland, so far as it is free of ice, are overlain by a narrow coastal belt of sandstones and shales, which lie

at low inclinations and have an aggregate thickness of 4,000 or 5,000 feet. No fossils have been found in this series, but it is provisionally regarded as of Tertiary age, like the plant-bearing beds, of similar lithologic character in the Disco region. Between the crystalline and the clastic rocks, "the discordance is very great and indicates that the crystalline terrane had assumed essentially its present attitude, had undergone very great erosion, and had approached its present topographic expression, before the sandstone was laid down upon it. If the sandstone were removed, the relief of the topography would apparently not be less than it is now, and not very different from it in general aspect."

The floe ice formed in Baffin bay was found to seldom exceed five or six feet in thickness; but the East Greenland current, sweeping around cape Farewell and running thence northward some five hundred miles in a belt adjoining the west coast, brings closely driven ice-floes, an impassable ice-pack, and these floes are commonly 15 to 20 feet thick and in some cases probably 30 feet or more. This great thickness is regarded as the result of freezing during several years, perhaps with increase by snowfall.

Few icebergs were drifted with the floes from East Greenland. Northward only a few others were seen, until a grand procession, thirty being in sight at once, was encountered streaming out southwesterly from Disco bay, into which they had been discharged by the Jacobshaven glacier. Another magnificent procession of icebergs was seen moving outward from the Umanak fjord. These were much larger but more tabular and less picturesque. Thirty or forty of large size, besides many smaller ones, were in view at the same time. In Inglefield gulf hundreds of icebergs were frozen in the floe-ice, which remained wholly unbroken in 1894 until August. Many of these bergs are doubtless held several years before they reach Baffin bay to be borne southward in the Labrador current. W. U.

Preliminary Report on the Physical Geography of the Litorina Sea. By HENR. MUNTHE. (Pages 1-38, with two maps, in vol. II, Bulletin of the Geological Institution of the University of Upsala, 1895.) Very thorough study is given in this paper to the diatoms, Rhizopoda, and Ostracoda, which occur in the Litorina deposits around the Baltic sea and the gulf of Bothnia. This work well supplements the valuable papers contributed by Baron De Geer to the Bulletin of the Geological Society of America (vol. III, pp. 65-68, with map) and the AMERICAN GEOLOGIST (vol. IX, pp. 247-249, April, 1892; vol. XI, pp. 22-44, Jan., 1893). The following stages in the history of the Baltic basin are ascertained:

1. *The time of the great Baltic glacier*, forming marginal moraines south and east of the present sea and gulf.

2. *Yoldia time*, when the land subsidence reached its maximum. The Baltic then received bergs and glacial rivers from the retreating ice, and was inhabited by *Yoldia arctica*, which now is restricted to Arctic regions, preferring the muddy waters where the sea has inflowing tributaries from glaciers. There was direct connection with the ocean by the Cattegat strait dividing Sweden and Denmark, and also across the

low lands of southern Sweden by the present lakes Wettern and Wenern, and probably northeast across the low area of lakes Ladoga and Onega to the White sea and Arctic ocean.

3. *Ancylus time*, when the Baltic basin, on account of gradual uplifting, became a great fresh-water lake, with shores in part since raised 50 to 150 feet above the present water level, outflowing through the Cattegat by a river which probably fell some 50 feet before reaching the North sea. The lacustrine fauna comprised *Ancylus fluviatilis*, *Limnæa ovata*, *Pisidia*, and other Mollusca, with fresh-water Ostracoda, and the climate was temperate.

4. *Litorina time*, when the area of the Cattegat and Danish archipelago sank somewhat lower than now, permitting inflow of marine currents to the Baltic so that it became salter and warmer than at present. Two species of *Litorina*, and others of *Scrobicularia* and *Rissoa*, extended north into the gulf of Bothnia, where now the water is too fresh for their existence. The uplift of the northern part of the Baltic basin since the Litorina time has ranged from 100 to 300 feet.

5. *Limnæa time*, when the strait and archipelago became more shallow, nearly as now. *Limnæa* species then immigrated where the *Litorinæ* had before flourished. This stage is perhaps scarcely distinct from the next.

6. *Mya time*, extending to the present day, characterized by the immigration of *Mya arenaria* from the North sea into the Baltic. W. U.

RECENT PUBLICATIONS.

I. Government and State Reports.

Bull. N. Y. State Museum, vol. 3, no. 11. Salt and gypsum industries of New York, F. J. H. Merrill. 89 pp., plates and maps, 1893.

The same, vol. 3, no. 12. Clay industries of New York, Heinrich Ries. Pp. 93-262, map, 1895.

II. Proceedings of Scientific Societies.

Proc. Acad. Nat. Sci. Phila., 1895, pt. 1. New and otherwise interesting Tertiary Mollusca, G. D. Harris; The Eocene Tertiary of Texas east of the Brazos river, Wm. Kennedy; Does the Delaware water gap consist of two river gorges, Emma Walter.

Bull. of the Geographical Club of Phila., vol. 1, no. 5, 1895. Report on geology, Peary Auxiliary Expedition of 1894, T. C. Chamberlin.

Journ. Elisha Mitchell Sci. Soc., vol. 11, part 2, 1894. History of the Atlantic shore line, H. L. Harris: An examination into the nature of Palæotrochis, C. H. White.

III. Papers in Scientific Journals.

Science, June 14, 1895. Current notes on physiography (IX), W. M. Davis: Volcanic dust in Utah and Colorado, Henry Montgomery: Volcanic dust in Texas, E. T. Dumble.

Science, June 21, 1895. On a Devonian limestone-breccia in southwestern Missouri, O. H. Hershey: Current notes on physiography (X), W. M. Davis.

Science, June 28, 1895. Some meandering rivers of Wisconsin, H. B. Kümmel.

Science, July 5, 1895. The submergence of western Europe prior to the Neolithic period, Agnes Crane; Current notes on physiography (XI), W. M. Davis.

Journ. of Geology, vol. 3, no. 4, May-June, 1895. Mesozoic changes in the faunal geography of California, J. P. Smith; The age and succession of the igneous rocks of the Sierra Nevada, W. H. Turner; The stratigraphy of the California Coast ranges, H. W. Fairbanks; Studies in the Neocene of California, G. H. Ashley; Some Cretaceous beds of Rogue River valley, Oregon, F. M. Anderson; Glacial studies in Greenland, V, The Redcliff peninsula, T. C. Chamberlin; Studies for students, Geologic study of migration of marine invertebrates, J. P. Smith.

Amer. Jour. Sci., July, 1895. Correlation of New York moraines with raised beaches of lake Erie, Frank Leveret; Pitch lake of Trinidad, S. F. Peckham; Some reptilian remains from the Triassic of northern California, J. C. Merriam; Further contribution to our knowledge of the Laurentian, F. D. Adams.

IV. Excerpts and Individual Publications.

On a granite-diorite from Harrison, Westchester county, N. Y., Heinrich Ries. Trans. N. Y. Acad. Sci., vol. 14, pp. 80-86, 1895.

The Protolenus fauna, G. F. Matthew. Ibid., pp. 101-153, pls. 1-11, 1895.

The effusive and dyke rocks near St. John, N. B., W. D. Matthew. Ibid., pp. 187-217, pls. 12-17, 1895.

A new fossil Nelumbo from the Laramie group, at Florence, Colo., Arthur Hollick. Bull. Torrey Bot. Club, vol. 21, pp. 307-310, July 20, 1894.

Wing-like appendages on the petioles of Liriophyllum populoides Lesq., and Liriodendron alatum Newb., with descriptions of the latter, Arthur Hollick. Ibid., pp. 467-475, pls. 220-221, Nov. 24, 1894.

Descriptions of new leaves from the Cretaceous (Dakota group) of Kansas, Arthur Hollick. Ibid., vol. 22, pp. 225-228, pl. 237, May, 1895.

The gold-silver veins of Ophir, California, Waldemar Lindgren. 14th Ann. Rept. U. S. G. S., pp. 243-284, pls. 17-18, 1895.

The origin of the Arkansas novaculites, L. S. Griswold. Proc. Boston Soc. Nat. Hist., vol. 26, pp. 414-421; Author's edition, Feb. 9, 1895.

Origin of the lower Mississippi, L. S. Griswold. Ibid., pp. 474-479; Author's edition, May 14, 1895.

Lansing lead mines, A. G. Leonard. Proc. Iowa Acad. Sci., vol. 2, pp. 36-38, 1895.

Cinnabar in Texas, W. P. Blake. Trans. Am. Inst. Mining Eng., Florida meeting, March, 1895; 8 pp.

Vein structure in the Enterprise mine, T. A. Rickard. Proc. Colorado Sci. Soc.: 8 pp., 6 pls.

PERSONAL AND SCIENTIFIC NEWS.

THOMAS HENRY HUXLEY died at Eastbourne, England, on June 29th, aged 75 years.

PROF. E. W. CLAYPOLE, of Buchtel College, is spending the summer months in England.

PROFESSOR G. C. BROADHEAD has been made Professor Emeritus at the State University of Missouri.

IN SYRACUSE UNIVERSITY DR. E. C. QUEREAU has been appointed professor of geology and mineralogy. (*Science.*)

CURTIS F. MARBUT of Harvard University has been appointed instructor in geology at the State University of Missouri. He also has charge of the topographical work of the Missouri Geological Survey.

DR. CARL BARUS, who is well known through his work in the division of chemistry and physics of the United States Geological Survey, becomes Hazard professor of physics in Brown University.

PROFESSOR W. H. SEAMON, member of the Geological Board of Missouri and professor of chemistry in the Missouri School of Mines, has been elected director of the New Mexico School of Mines at Socorro.

MR. W. N. MOORE. who has been in charge of the forecasting office of the Weather Bureau at Chicago, is now chief of the United States Weather Bureau, having succeeded Prof. Mark W. Harrington.

PROFESSOR J. J. STEVENSON, of the University of the City of New York, will spend the summer in the coal fields of Arkansas, Indian Territory and Texas, with incidental studies in New Mexico and Colorado. (*Science.*)

SILAS WATSON FORD died at Saratoga, N. Y., June 25th, aged 48 years. Mr. Ford's name is familiar to American paleontologists through his papers on the fauna of the Silurian and Cambrian, which were published from 1871 to 1886.

THE NEW YORK STATE MUSEUM announces the following bulletin (Vol. 3, No. 14) as in press: "Geology of Moriah and Essex Townships, Essex Co., with Notes on the Iron Mines," by J. F. KEMP. A bulletin (Vol. 3, No. 15) on the "Mineral Resources of New York," by F. J. H. MERRILL, is in preparation.

AT THE COMMENCEMENT EXERCISES AT YALE UNIVERSITY Prof. George Fisher introduced a resolution of regret, which was unanimously adopted, on the death of Prof. JAMES DWIGHT DANA. He announced that if $4,500 more were raised, a pedestal and bust of the late professor would be erected on the campus. (*Science.*)

MR. ARTHUR WINSLOW has published a list of errata and acknowledgements for his report on the "Lead and Zinc Deposits of Missouri" (Mo. Geol. Survey, vols. 6 and 7). This list was not inserted in the report and Mr. Winslow will be glad to send a copy of the list to any one receiving the report who will apply to him. His address is: Rooms 411 and 412, Roe Building, St. Louis, Mo.

THE MICHIGAN MINING SCHOOL has recently issued a "Prospectus of elective studies," which states that the school will this fall adopt an elective system. Students are allowed to select one of several courses with a certain principal subject, and in each course certain studies are required and the rest are elective. The school thus allows greater freedom in the selection of studies than do most mining schools.

THE GLACIALISTS' MAGAZINE begins its third volume as a quarterly, of which the first part bears the date of June, 1895. Its leading article in this number is by Dr. Karl Grossmann and J. Lomas, on the glaciation of the Faröe islands, with a map of this group on the scale of three miles to an inch, and several sections and views. Communications for the magazine are to be addressed to the editor, Percy F. Kendall, Chapel Allerton, Leeds, England. The annual subscription price remains at six shillings, which may be sent to Arthur R. Dwerryhouse, 8 Livingston Avenue, Sefton Park, Liverpool.

SIXTH INTERNATIONAL GEOGRAPHICAL CONGRESS. The meetings in London from July 26th to August 3d have been mentioned in previous numbers of the AMERICAN GEOLOGIST. It is announced that there will be several short excursions for members of the Congress about London and the vicinity. A limited excursion will start for the English Lake district under the guidance of MR. J. E. MARR, F. R. S., a geologist who has made this district his special study. PROFESSOR JAMES GEIKIE will conduct a geological and geographical excursion in the neighborhood of Edinburgh, and this will be followed by a physico-geographical excursion to the Scottish highlands, of a week's duration, which will be under the guidance of an experienced field geologist.

UNIVERSITY OF MINNESOTA. The instruction in geology and mineralogy is under the direction of DEAN C. W. HALL, professor of geology and mineralogy. He will be assisted by MR. C. P. BERKEY, instructor in mineralogy, and by MR. A. H. ELFTMAN, laboratory assistant. Ten courses in geology and seven in mineralogy are open to undergraduate students, and six special courses are offered to graduate students. In the College of Engineering, Metallurgy and the Mechanic arts eleven courses in geology and mineralogy are open to students who make either mining, metallurgy, or chemistry a specialty.

MR. F. W. DENTON, formerly professor of mining and civil engineering in the Michigan Mining School, and at present mining engineer for the Minnesota Iron Company, will this fall assume the duties of associate professor of mining and metallurgy.

JOHNS HOPKINS UNIVERSITY. At the annual commencement an oil portrait of the late PROFESSOR GEORGE HUNTINGTON WILLIAMS was presented to the university by PROFESSOR WM. B. CLARK on behalf of the former students and colleagues of Professor Williams. PRESIDENT GILMAN announced that the widow of Professor Williams had given a sum sufficient to establish a lectureship in geology in commemoration of her husband. The trustees of the university have invited as the first lecturer SIR ARCHIBALD GEIKIE, director of the Geological Survey of Great Britain and Ireland. MESSRS. G. K. GILBERT and BAILEY WILLIS, of the U. S. Geological Survey, who have given special courses of lectures in geology the past year, will give similar courses the coming year. DR. E. B. MATHEWS, instructor in mineralogy, has been promoted to be associate in mineralogy. The degree of Doctor of Philosophy was conferred upon the following gentlemen who have been pursuing geological studies: RUFUS MATHER BAGG, of West Springfield, Mass.; SAMUEL WALKER BEYER, of Ames, Iowa; HENRY STEWART GANE, of Chicago, Ill. Mr. Bagg's thesis was entitled, "The Cretaceous Foraminifera of New Jersey;" he is assisting Prof. W. B. Clark in his work on the Eocene of the Atlantic Coastal plain. Mr. Beyer's thesis was entitled, "The Sioux Quartzite near Sioux Falls in South Dakota, with especial reference to an Intrusive Diabase;" he becomes assistant professor of geology and zoology in the Iowa Agricultural College, and is also connected with the Iowa Geological Survey. Mr. Gane's thesis was on "The Neocene Corals of the United States;" he becomes an assistant on the U. S. Geological Survey and this summer will work under Dr. Whitman Cross in Colorado.

THE GEOLOGICAL SOCIETY OF AMERICA announces a week's excursion through the crystalline area of western Massachusetts. This will be under the direction of PROFESSORS B. K. EMERSON and WM. H. HOBBS. Geologists desiring to join this excursion will meet on Monday evening, August 19th, at the American House in Pittsfield, Mass. The party will reach Springfield early Tuesday morning, August 27th, in time for the opening session of the Geological Society. It is particularly desired that all persons who wish to join in this excursion should communicate in advance with Prof. B. K. Emerson, Amherst, Mass. The following geological excursions are proposed for the week of the meetings:

(1) Russell and Chester on the Boston & Albany R. R. The kaolin quarries at Blandford, the Atwater marble quarry at Westfield, and the emery mines at Chester will be visited on

this trip. These formations illustrate the crystalline rocks west of the Connecticut river. PROFESSOR W. O. CROSBY, of Boston, will accompany the party which makes this excursion.

(2) An excursion to study the Triassic sandstones and also contacts of these rocks with the Holyoke trap sheets and intrusives. This trip will include Mount Tom and Mount Holyoke. PROFESSOR B. K. EMERSON, will conduct this excursion.

(3) PROFESSOR W. M. DAVIS, in connection with PROFESSOR WILLIAM NORTH RICE, has arranged for an excursion to Meriden and Southington, Connecticut. This region affords fine examples of contact between the older crystalline rocks and sandstone. The Meriden quarry exhibits lava flows and faults.

PROFESSOR ROBERT BELL, of the Geological Survey, read a paper on "A great pre-glacial river in northern Canada" at the annual meeting of the Royal Society of Canada held at Ottawa in May last. It was the outcome of much study and extensive observation in the North. The paper was illustrated by a map. The following short abstract is from the *Ottawa Journal*.

"It was," he said, "generally conceded by geologists that just before the advent of the glacial epoch, the continent of North America stood at a considerably greater elevation than at present, the difference according to some authorities, amounting to two or three thousand feet, if not more. The difference was greater towards the south, as compared with the present general altitudes. The inevitable result of this would be to greatly alter the river systems. We should find in northern Canada a wide central drainage area equal to about one-third of the present land surface of the continent, the center of which would be in the region now covered by Hudson bay.

"This great inland sea does not average 400 feet in depth, and it would be all dry land even with a very moderate elevation.

"Hudson Strait is much deeper and it would either form a long bay or a river valley, according to the amount of the continental elevation.

"Some geologistsats think that about this time the upper part of the St. Lawrence basin, including all the lakes, except Ontario, discharged its waters northward from lake Superior. But even without this doubtful part, the drainage area of this one great northern river would be seven times that of the present St. Lawrence. Judging from the ancient erosion of the valleys and from other considerations, the annual precipitation was at least as great then as now, so that this former river must have been of gigantic proportions compared with any river of the present world.

"Its catch-basin would extent from the sources of the Saskatchewan and the Athabasca beyond the Rocky mountains to near the eastern coast of Labrador, and from the Minnesota river in the south to the northern part of Baffin land, and would also include the southern part of the great McKenzie basin. It would flow through the centre of Hudson bay and down Hudson strait. The former existence of this great river was not a mere speculation as to what might have been, but a necessary consequence of the elevation and change in the slope of the land, and it was proved in detail by a multitude of concordent facts all over the territory involved."

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Edward Hitchcock

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AMERICAN GEOLOGIST.

VOL. XVI. SEPTEMBER, 1895. No. 3.

EDWARD HITCHCOCK.

By C. H. HITCHCOCK, Hanover, N. H.

[Portrait, Plate VII.]

Edward Hitchcock, the youngest of five children, and of the sixth American generation of an English family, was born at Deerfield, Massachusetts, in 1793. He died at Amherst, Massachusetts, in 1864, having nearly completed his seventy-first year.

An ardent desire for knowledge impelled him to acquire by himself many of the branches of learning usually taught in colleges, but at hours devoted by his associates to recreation and repose. His tastes were shaped at first by a maternal uncle, Gen. Epaphras Hoyt, being directed towards astronomy and military engineering. His first study was the determination of the longitude of his native town by observations upon the total eclipse of the sun in 1811. For three months and a half he took observations upon the distance of the comet from various stars, on the latitude and longitude by lunar distances and eclipses of the sun and moon and on the variation of the magnetic needle. Then it required several months to reduce the observations, and as he had very few books he was obliged to calculate many elements by spherical trigonometry, which are found to-day in practical astronomical tables. The results as applied to the longitude of Deerfield church were given by Gen. Hoyt in the Memoirs of the American Academy of Arts and Sciences for 1815, vol. III, p. 307-9. Few young men of

eighteen labor more diligently than he did in this amateur effort. A still more improving discipline was developed from this. In making his calculations he made much use of Blunt's Nautical Almanac, which was a reprint from the highest English authority. Beneath the opening page for every month appeared this sentence, "Ten dollars will be paid on the discovery of an error in the figures." This led to an examination and to the discovery of many errors, which were communicated to Mr. Blunt, who took no notice of them. He then sent the list to the American Monthly Magazine. This excited Mr. Blunt's indignation and he endeavored to evade the force of the errors by representing that they occurred only in that part of the tables used by astronomers and not in that used by seamen, and charged Hitchcock with shameful neglect in not examining this more practical portion. The answer to this reproach was the discovery of twenty errors of such magnitude in the navigation tables as to lead to disaster if dependence were placed upon them. Further calculations led to the discovery of eighty errors in all in four or five of these almanacs, and to an apology from the editor. One can see that rigid accuracy was indispensable for the discovery of these errors with corresponding application. The discipline thus obtained was the same in kind with that of a college course, which through a failure of health he was not able to acquire. Other discipline and a knowledge of the classics was acquired by holding the principalship of Deerfield Academy for four years. He learned much of English by taking an active part in a village debating society. During these years he wrote some poetry, particularly a tragedy, entitled the "Downfall of Bonaparte," which was both published and acted with great success before his neighbors and friends.

The decade from 1810 to 1820 was an active one in theological thought in New England, it being the time of the Unitarian controversy. Young Hitchcock had sided with the Unitarians at first, but on further reflection became satisfied that the truth lay on the orthodox side, and was induced to devote himself to the ministry. He fitted himself for this office in the theological department of Yale College and was settled as pastor of the Congregational church of Conway, Massachusetts, from 1821 to 1825.

While seeking for some means of promoting health he was led to study plants, animals and minerals, and to the acquaintance of Prof. Benjamin Silliman. Doubtless the love for science led him to Yale, where he might derive some collateral instruction besides his theology. The early volumes of the American Journal of Science contain many papers based upon his early observations, and a lifelong friendship ensued between the teacher and the scholar. In 1825 Hitchcock was appointed professor of chemistry and natural history in Amherst College and filled this chair till elected to the presidency of the same institution in 1845. After nearly ten years of service he returned to the professorial ranks, teaching only geology and its relations to theology for another decade.

A complete biography would find materials for three classes of activity. *First*, he was a philanthropist, theologian and devoted minister of the gospel. He believed in the truths of christianity and labored as he had opportunity to better the moral condition of society. *Second*, he was a college professor and president and achieved success both in the lecture room and in the management of a literary institution. By his prudence and skill he saved the college from threatened collapse. A burdensome debt was removed, handsome endowments secured and the number of students more than doubled during his administration. *Third*, he was a geologist and his greatest successes were connected with this phase of activity. Only this part of his work will be here considered.

The subject of surface geology occupied the attention of Mr. Hitchcock from the very beginning of his researches. In 1823 he explained the origin of deltas, terraces, dispersion of drift and polished rock surfaces by the action of moving waters or floods. Glaciers were unknown to him and were not referred to by any geologist as productive of drift phenomena before 1838 when Agassiz first promulgated the glacier theory. What are now distinctly known to be moraines were correctly described and figured in 1833 as "diluvial elevations and depressions" and it was not till 1842 that he ventured to call them moraines, after Agassiz, Buckland, and Lyell. In the presidential address of 1841 before the American Association of Geologists the main phenomena and facts of glacial dispersion are correctly described and he seemed almost ready to

accept the glacial theory. Indeed, Murchison pronounced him a glacialist from the reading of this address, but the adoption of the term "glacio-aqueous action" for the drift showed that the agency of icebergs appeared the more important. There were three difficulties in his way: first, the immense area occupied by the supposed ice-sheet, far greater than any known system of glaciers; second, the transport of boulders from lower to higher levels, as from the St. Lawrence valley to the tops of the Green mountains and beyond; and third the presence of the enormous moraines near the sea coast in Massachusetts. He once remarked upon the possibility that these hillocks might have been the terminal moraines of this imagined ice-sheet, which is the earliest allusion to such a view that can be found anywhere in the annals of American geology.

After returning from Switzerland he discovered in western Massachusetts the moraines and glacial markings of real glaciers, which he distinguished carefully from the phenomena of general drift supposed to have been produced by icebergs. Later discoveries enabled him to generalize and advocate the presence of glaciers upon the summits of the White and Green mountains and other equally high mountains by inference, from which bergs broke off and floated away more or less radially. But he was careful to explain that this was a local glaciation and entirely distinct from the general drift, which still seemed to him to have been produced mainly by floating and shore ice. As his early life had been spent in a region where the terraces are unusually perfect, he was led naturally to adopt theories which would explain their origin, and thus he made much of the distinction between the drift and the modified drift, asserting that the terraces had been derived from a re-working or assorting of the ice-made accumulations. It was the careful study of terraces that led to the preparation of the Illustrations of surface geology published by the Smithsonian Institution in 1857. This was, to that date, the most complete treatise upon surface geology that had been published in the United States. It is to his credit that he did not allow himself to be led astray by any fanciful theory like that proposed by the brothers Rogers, who were his contem-

poraries. Hitchcock never hesitated to say, "I do not know,"* when existing theories failed to be reasonably satisfactory. This was especially obvious in his treatment of the celebrated Berkshire trains of boulders. Had he lived two years longer, he would have probably adopted the glacial theory, as by that time it had become obvious that the immensity of the glacial area and the ascent of the ice thousands of feet were no bar to its adoption; and he would then have been the first to see a terminal moraine in the hillocks of cape Cod and Long island.

The name of Edward Hitchcock is more thoroughly identified with the subject of ichnology and the Connecticut sandstone. To him belongs the honor of having proved the existence of a large fauna of giant bipeds and quadrupeds in the trias of New England from their footmarks. When he first examined the track of the large *Brontozoum* some eighteen inches in length, he threw away the slab, supposing it merely an accidental resemblance, but very soon he discovered that the accidents were the law in this case and the large creatures were very plenty. It was the description of these gigantic footmarks that fortified Prof. Owen, of London, in his belief in the existence of the *Deinornis* of New Zealand. The bibliography shows how numerous and varied were the papers illustrating these ichnites. The footmarks gave the first proofs of the existence of Deinosaurs, although they received the name of "ornithoid lizards or batrachians." The final classification of Prof. Hitchcock summarized the groups as follows: one marsupial; seventeen pachydactylous birds; seventeen leptodactylous birds; twenty-one ornithoid reptiles; twenty-five reptiles and Amphibia; seventeen Batrachia; six Chelonia; two fish; twenty-four insects; twenty-one inferior Arthropoda or larvae; and ten Mollusca, or over one hundred and fifty in all. There is a fine collection of these Ichnozoa at Amherst, where a room one hundred by thirty feet, with two smaller ones, are filled by numerous slabs, exhibiting over 20,000 distinct impressions, all gathered by Edward Hitchcock and named after him since his decease. A fine marble bust by Millmore adorns one of the shelves.

*My brother adds as very characteristic of our father, that he should acknowledge that he made a mistake in calling the lizards and batrachians birds at the first.

Perhaps greater originality is indicated by his discoveries of distorted and metamorphosed pebbles in conglomerates. As far back as 1833 he noticed these elongated pebbles near Newport, R. I., and briefly described them in his reports of 1833, 1835, and 1841. In 1859 additional localities showing greater distortions and alterations were found on both sides of the Green mountains. The following conclusions he derived from the Rhode Island illustrations: 1. The rock was once a normal conglomerate, with the ordinary waterworn rounded pebbles, which have been elongated, flattened, bent and indented by some subsequent agency. 2. The pebbles were somewhat plastic before distortion. 3. Pebbles upon existing beaches do not exhibit any such distortions. 4. Some of the pebbles have been cut by joints. 5. The forces producing the alterations are the same that have produced plication. From the more northern examples it may be said further, 6, that in Vermont the elongation and flattening operated most energetically in the direction of the dip, while it had been in the direction of the strike in Rhode Island. 7. This was often effected by minute folding. 8. Some of these conglomerates after extreme flattening have been altered into crystalline schists, partly by chemical changes, partly by mechanical flexing. This may be done in many cases without obliterating entirely the original fragmental shapes. It is not to the credit of American geologists that so many of them refused to accept these views till they were forced to do so by the petrographical studies entered upon by Europeans. The microscope has fully confirmed and enlarged our views respecting the origin of many schists from sediments, through mechanical and chemical alteration of the constituent fragments.

Edward Hitchcock also performed eminent service in conducting geological surveys and in establishing scientific associations. It was his success in conducting explorations in Massachusetts that led to the inauguration of similar surveys simultaneously in 1836 in all the important states in the then existing Union. The government of New York consulted him as to the best method of surveying that great state, and his advice that it be divided into four districts was followed, and he was appointed to the charge of the survey of the first district. He entered upon the work with C. B. Adams for assist-

ant, but thought best to resign, largely to endeavor to urge the importance of a re-survey of Massachusetts. This effort was successful and the final results appeared in 1841. Further researches in ichnology and certain special topics appeared in 1853 and 1859 as a part of this state survey. In 1857 he was persuaded to direct the state survey of Vermont, whose results appeared in 1861.

For several years he had labored to bring the working geologists of the country together to confer and compare results. This was the origin of the American Association of Geologists, who met for the first time at Philadelphia in 1840, and he was the first president. This company invited the naturalists to join them the following year, and the organization was known as the American Association of Geologists and Naturalists until 1848, when, by the addition of the physicists the society became the American Association for the Advancement of Science. The meetings of this society he always attended and took prominent part in its sessions as indicated by the records.

A very appreciative biographical sketch was prepared and read by Prof. J. P. Lesley before the National Academy of Sciences in 1866. To this and to his autobiography we must refer those who wish for a fuller information than can be given here. The portrait (plate VII) represents him as he appeared not far from the age of fifty-five.

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1836. Sketch of the Geology of Portland, Maine, and its vicinity, and map. Id., vol. I, pages 41.

1836. Ornithichnology. Description of the Footmarks of Birds. (Ornithichnites) on New Red Sandstone in Massachusetts. Am. Jour. Sci., vol. XXIX, 33 pages, 4 plates.

1836. Ornithichnology Defended. Knickerbocker, 6 pages.

1836. Remarks on Professor Stuart's Examination of Gen. I in reference to Geology. Biblical Repository for April; pp. 39.

1836. Ornithichnites in Connecticut. Amer. Jour. Sci., vol. XXIX, 2 pp.

1837. Argument for Early Temperance, addressed to the youth of the United States. Altered and enlarged from the Prize Essay. Reprinted in London, 89 pages.

1837-8. The Historical and Geological Deluges Compared. The Biblical Repository and Quarterly Observer, Jan. and Oct. '37, Jan. '38, 127 pages. Republished in the Biblical Cabinet, Edinburgh.

1837. Fossil Footsteps in Sandstone and Greywacke. Am. Jour. Sci., vol. XXXII, pages 3.

1837. Scene on the Banks of the Connecticut. Knickerbocker.

1837. Preface (5 pp.) and notes of the American edition of Researches in Theoretical Geology. By H. T. De LaBeche.

1838. Report on a re-examination of the Economical Geology of Massachusetts; 139 pages.

1839. A Wreath for the Tomb. 12 mo., 250 pages. Second edition in 1842. Reprinted in London, 1842, with an introduction by Dr. J. Pye Smith.

1839. Analysis of Marl from Farmington, Ct. 1 page, Am. Jour. Sci., vol. XXXVI.

1840. Elementary Geology; 329 pages, 2 plates, 122 wood cuts. Eighth edition in 1847, 361 pages.

1840. Specimens of Minerals and Rocks from Heidelberg; 2 pages, Am. Jour. Sci., vol. XXXIX.

1841. First Anniversary Address before the Association of American Geologists. Philadelphia: Am. Jour. Sci., with proceedings of the meeting, vol. XLI, 46 pages.

1841. Final Report on the Geology of Massachusetts. In four parts. I, Economical Geology; II, Scenographical Geology; III, Scientific Geology; IV, Elementary Geology; 844 pages, 52 plates.

1842. Description of the Scenery of Berkshire Co., Mass. Boston Recorder.

1842. Description of the Scenery of the White Mountains, N. H. Boston Recorder.

1842. Review of a Muck Manual for Farmers. By S. L. Dana; 6 pages. Am. Jour. Sci., vol. XLIII.

1842. Remarks upon Mr. Murchison's Anniversary Address before the London Geological Society. Three pages, Am. Jour. Sci., vol. XLIII.

1842. The Waste of Mind. Address at the Anniversary Exercises at the Mt. Holyoke Seminary: 66 pages.

1843. The Phenomena of Drift or Glacio-Aqueous action in North America between the tertiary and alluvial periods. Reports of the Association of American Geologists and Naturalists at Philadelphia in 1840 and 1841, and at Boston in 1842; 58 pp.

1843. Description of five new species of Fossil Footmarks from the New Red Sandstone from the Valley of Connecticut River. Id., 10 pages.

1843. Description of several species of Fossil Plants from the New Red Sandstone Formation of Connecticut and Massachusetts. Id., 9 pages.

1843. Notes on the Geology of several parts of Western Asia; founded chiefly on specimens and descriptions from American missionaries. Id., 74 pages.

1843. Exhibition of casts of all the Fossil Footmarks of the Connecticut valley.

Copper in the drift of Mass. and occurence of Yttrocerite.

Discussion of C. T. Jackson's paper on the Drift; 4 pages. Proc. Amer. Assoc. Geol. and Nat. Albany meeting.

1843. Vibrating Dams. Am. Jour. Sci., vol. XLV, 2 pages.

N. D. Obituary notice of Mrs. Prof. W. C. Fowler. N. Y. Observer.

1843. Letter introducing a communication from Peter Dobson on the Iceberg Theory of Drift. Am. Jour. Sci., 1 page, vol. XLVI.

1844. Analysis of Wines from Palestine, Syria and Asia Minor, and of specimens of American Cider. Am. Jour. Sci., vol. XLV, 9 pages.

1844. Upon Lincolnite. Amer. Jour. Sci., 1 page, vol. XLVII.

1844. Washington meeting of A. A. G. and N. New York Journal of Commerce.

1844. Report on Ichnolithology or Fossil Footmarks, with a description of several new species and the coprolites of birds, from the valley of Connecticut River, and of a supposed footmark from the valley of the Hudson River. Read before Amer. Assoc. Geol. and Nat., and published in Amer. Jour. Sci., vol. XLVII, 31 pages, 2 plates.

1844. Discovery of more native Copper in the town of Whately in Massachusetts in the valley of Connecticut River, with remarks upon its origin. Id., vol. XLVII, 2 pages.

1844. Trap Tufa or Volcanic Grit of the valley of Connecticut River with inferences as to the relative age of the trap and sandstone.

Report on Ichnolithology or Fossil Footmarks, with a description of the Coprolites of Birds discovered recently in the Connecticut valley, etc.

Dispersion of blocks of Stone in the Drift period in Berkshire County.

Remarks on papers of Douglass Houghton and Dr. Samuel Webber. Abstracts of these five topics in Proc. Amer. Assoc. Geol. and Nat., Washington meeting.

1844. Rejoinder to the "Discovery of Fossil Footmarks," by J. Deane. Amer. Jour. Sci., vol. XLVII, 10 pages.

1844. Discovery of the Yttrocerite in Massachusetts. Read before Assoc. Amer. Geol. and Nat., at Albany, 1843. Id., vol. XLVII, 2 pages.

1844. Analysis of Coprolites from the New Red Sandstone formation of New England. By Samuel L. Dana, with remarks by Prof. Hitchcock. Amer. Jour. Sci., vol. XLVIII, 16 pages.

1844. Extract from a letter embracing miscellaneous remarks upon Fossil Footmarks, the Lincolnite, and a letter from Prof. Richard Owen on the great birds-nests of New Holland. Id., vol. XLVIII, 4 pages.

1844. Geological Map of Massachusetts, on rollers. Accompanied by a pamphlet; 22 pages.

1845. The Highest use of Learning. Inaugural address when inducted into the Presidency of Amherst College; 45 pages.

1845. The Coronation of Winter. Two editions; 24 pages.

1845. Supplement to notes on the Geology of Western Asia.

An attempt to name, classify and describe the animals that made the fossil footmarks of New England.

Remarkable facts respecting the Magnetic Polarity of Trap rocks in New England.

Abstracts of these three papers published in Proc. Sixth Meeting of Assoc. Geol. and Nat., New Haven.

1845. The American Academic System Defended. Address at Williston Seminary; 29 pages.

1845. Optical Delusions in Sickness. 3 pages, New Englander, vol. III.

1845. Description of a singular case of the dispersion of blocks of Stone connected with Drift in Berkshire county, Mass. Read before the A. A. G. and. N., Washington, 1844. Amer. Jour. Sci., vol. XLIX, 8 pages.

1845. Letter to C. B. Adams upon the Geology of Vermont. First report upon the Geology of Vermont. By C. B. Adams; 5 pp.

1846. Letter to C. B. Adams upon the Geology of Vermont. Id. Report upon the Geology of Vermont. By C. B. Adams; 6 pp.

1847. Virginia and Midlothian Coal Mines in Hampshire and Franklin Express and the Richmond Watchman and Observer.

1847. Description of two new species of Fossil Footmarks found in Massachusetts and Connecticut, or of the animals that made them. Amer. Jour. Sci., N. S., 11 pages, vol. IX.

1847. On the Trap Tuff or Volcanic Grit of the Connecticut Valley, with the bearings of its history upon the age of the Trap Rock and Sandstone generally in that valley. Amer. Jour. Sci., N. S., vol. IV. 9 pages.

1847. Religious Lectures on Peculiar Phenomena in the Four Seasons. Four plates. 2d ed. in 1851; 3rd ed. in 1861, with additions; 176 pages. Also reprinted in London.

1847. Last Hours of Prof. N. W. Fiske. Hampshire and Franklin Express.

1847. Brief Address at the Inauguration of Edward Everett as president of Harvard College.

N. D. On the Potato Rot. Hampshire and Franklin Express.

1848. Cars Ready. A tract of four pages; published by the American Tract Society.

1848. The Blind Slave in the Mines. Id., 4 pages.

1848. The Fossil Footmarks of the United States, and the animals that made them. Trans. Amer. Acad. Arts and Sci., vol. III. 128 pages, 26 plates.

1848. Address before a committee of the Massachusetts Legislature in behalf of Amherst College. 7 pages.

1848. Dedication of the Wood's Cabinet and Lawrence Observatory at Amherst College. 6 pages and editorship of 45 pages.

1849. Popular description of the new cabinet and observatory of Amherst College. Originally published in Hampshire and Franklin Express. Pamphlet. 19 pages.

1849. A Chapter in the Book of Providence. Address at Mt. Holyoke Seminary. 42 pages.

1849. On the River Terraces of the Connecticut Valley and on the Erosions of the Earth's Surface. Proc. A. A. A. S., Cambridge meeting; 9 pages.

1849. Naming Mt. Toby anew. Hampshire and Franklin Express.

1849. Mesmeric meeting of the class of 1849. Id.

1850. The Inseparable Trio. An Election sermon before Governor Briggs. 45 pages.

1850. History of a Zoological Temperance Convention held in central Africa in 1847. 100 pages; several editions.

1850. Revival of Religion in Amherst College. Hampshire and Franklin Express.

1850. On terraces. Proc. British Assoc. Adv. Sci.

1850. Five letters from Europe in New York Observer.

1851. Religion of Geology and its Connected Sciences. 311 pages; new edition enlarged to 392 pages in 1859. Reprinted in London in 1851, 1855, 1859.

1851. Report of commissioners concerning an agricultural school in Massachusetts. Official document. 94 pages, giving report of observations upon agricultural schools visited in Europe.

1851. On the separation of Butter from Cream by Catalysis. Proc. A. A. A. S., Albany meeting. 2 pages.

1851. On the Terraces and Sea Beaches that have been formed since the Drift Period, especially those along the Connecticut River. Id., 6 pages.

1851. On the Geological age of the Clay Slate of the Connecticut Valley in Massachusetts and Vermont. Id., 1 page.

1852. The Catalytic Power of the Gospel. A sermon before Mass. Home Miss. Society. 32 pages.

1852. Description of a Slide on Mt. Lafayette at Franconia, New Hampshire. Amer. Jour. Sci., N. S., vol. XIV, 4 pages.

1852. The Power of Christian Benevolence Illustrated in the Life and Labors of Mary Lyon. 486 pages, of which 200 were written by E. H.

1853. Report on certain points in the Geology of Massachusetts-Coal Field, Bristol Co. Iron ores of Berkshire. Ancient Glaciers. 46 pages. Official document.

1853. Description of a Brown Coal Deposit in Brandon, Vt., with an attempt to determine the Geological Age of the principal Hematite ore beds in the United States. Amer. Jour. Sci., N. S., vol. XV, 10 pages.

1853. Geology of the route traversed by Capt. R. B. Marcy in Texas, etc. 16 pages.

N. D. Murderers of Fathers and Murderers of Mothers. 12 pages. Tract published by the American Tract Society.

1853. Relations and Mutual Duties between the Philosopher and the Theologian. Address before Porter Rhetorical Society. A. T. S. Bibliotheca Sacra: 45 pages.

1853. Special Divine Interpositions in Nature. Address before theological seminaries of Bangor and Newton. Bib. Sac. for 1854; 34 pages.

1853. Report on Soapstone of Middlefield, Mass., to Metropolitan Soapstone Co. of New York. 4 pages.

1853. Outline of the Geology of the Globe and of the United States in particular, with two maps and six plates of fossils. 136 pages; several editions.

1853. Introduction to Genesis and Geology, by Dennis Crofton. 1 page.

1854. The Plurality of Worlds. Introduction to American Edition. 8 pages.

1854. Valedictory address on leaving the presidency of Amherst College. 27 pages.

1854. A Sister's Deathbed. Recorder.

1854. Charge to Dr. Stearns at his installation as pastor of the Amherst College church. 8 pages.

N. D. Geology of the Hoosac Mountain. Testimony before committee of the legislature. 4 pages.

1855. Lecturing tour in the west. Congregationalist.

1855. Report on Coal Lands to the Great Kanawha Company, West Va. 8 pages.

1856. Report on Soapstone of Newfane, Vt., to Vermont Marble and Soapstone Co. 6 pages.

1856. On a new Fossil Fish and new Fossil Footmarks. Amer. Jour. Sci., N. S., vol. XXI: 4 pages.

1856. Illustrations of Surface Geology. 155 pages, 12 plates. From vol. IX of Smithsonian Contributions to Knowledge.
Reprinted with an addition of two pages in 1860.

1856. Address at the inauguration of the State Geological Hall at Albany; 7 pages. Printed in the Tenth Annual Report of the Regents of the University.

1855. Description of several sections measured across the sandstone and trap of Connecticut river valley in Massachusetts.
Additional facts respecting the tracks of the Otozoum Moodii on the Liassic sandstone of the Connecticut valley.
Account of the Discovery of the Fossil Jaw of an extinct family of sharks from the Coal Formation. Abstract of three papers presented at the Providence meeting A. A. A. S.; five pages.

1856. The Religious Bearings of Man's Creation; 31 pages. A sermon preached during the Albany meeting of the A. A. A. S. Published by Local Committee.

1856. Sermon at the funeral of Rev. Dr. Theopilus Packard, preached at Shelburne, Mass., in 1855. 23 pages.

1857. Religious Truth illustrated from Science, in addresses and sermons on special occasions. 422 pages.

1857. Description of a large boulder in the Drift of Amherst, Massachusetts, with parallel striae upon four sides. Amer. Jour. Sci., N. S., vol. XXII; 3 pages.

1857. Report on the Geological Survey of the State of Vermont. Official state document. 12 pages.

1858. Report on the Geological Survey of the State of Vermont. Official state document. 13 pages.

1858. Ichnology of New England. A report on the sandstone of the Connecticut valley, especially its footmarks; made to the government of Massachusetts. 232 pages; 60 plates.

1858. Sermon at the funeral of Mrs. Mary Ann Woodbridge, preached at Hadley, Mass., Jan. 20. 15 pages.

1858. The United States a Commissioned Missionary Nation. A discourse delivered in the chapel of Amherst College Sept. 26. 29 pages.

1859. Address on the presentation of silver plate from faculty and students of Amherst College.

N. D. Alexander Mar. Hampshire and Franklin Express.

1859. Catalogue of the Massachusetts State Cabinet under the charge of the Sec'y of the Board of Agriculture. 69 pages. From the report of the Secretary.

1859. Report to the Hunterdon (N. J.) Copper Company. 1 page.

1859. Preliminary Report on the Geology of Vermont. Official state document; 16 pages.

1859. Who first scientifically investigated and described fossil footmarks in the Connecticut valley? Two issues of the Springfield Republican in May.

1860. Remarks upon certain points of Ichnology. 13 pages.

On certain conglomerated and brecciated trachytic dikes in the Lower Silurian rocks of Shelburne, Vt., with special reference to the degree of heat at the time of their production. 3 pages.

Additional facts respecting the Clathropteris of Easthampton, Mass. 1 page. Read at the Newport meeting of the A. A. A. S.

1860. Elementary Geology. 31st edition: 430 pages. Entirely rewritten with the assistance of C. H. Hitchcock.

1860. Letter to New York World dated Oct. 8, concerning a memoir of Mary Lyon.

1860. Exegesis of 1 Cor. XV. 25-44. Bibliotheca Sacra. 10 pages.

1860. Distorted pebbles. Proc. Boston Soc. Nat. Hist., 1 page, vol. VII.

1860. Elementary Anatomy and Physiology. By E. Hitchcock and E. Hitchcock, Jr.: 441 pages. First and last chapters: 43 pages.

1860. The West Parish Cemetery, Amherst, Mass. Hampshire and Franklin Express.

1861. On the conversion of certain conglomerates into talcose and micaceous schists and gneiss, by the elongation, flattening and metamorphosis of the pebbles and the cement. Amer. Jour. Sci., N. S., vol. XXXI, 21 pages.

1861. Geology of Vermont; Descriptive, Theoretical, Economical and Scenographical. By Edward Hitchcock, Edward Hitchcock, Jr., A. D. Hager and C. H. Hitchcock. 2 vols; 988 pages; 38 plates; of this E. H. prepared 211 pages.

1861. The Cross in Nature and Nature in the Cross. 31 pages. Bibliotheca Sacra, vol. XVIII.

1861. Address at Mt. Holyoke Seminary at its 25th anniversary.

1862. Supplement to the Ichnology of New England. Proc. Amer. Acad. Art and Sciences., vol. VI, 8 pages.

1862. The Visitor's Guide to the Public Rooms and Cabinets of Amherst College. By C. H. Hitchcock. 51 pages prepared by E. H.

1863. A Gorilla at Amherst. Congregationalist.

1863. New facts and conclusions respecting the Fossil Footmarks of the Connecticut valley. Amer. Jour. Sci., N.S., vol. XXXVI, 11 pages.

1863. The law of Nature's constancy subordinate to the higher law of change. Bibliotheca Sacra, vol. xx, 72 pages.

1863. Reminiscences of Amherst College, Historical, Scientific, Biographical and Autobigraphical; also of other and wider life experiences. 4 plates and map. 420 pages.

1865. Supplement to the Ichnology of New England. Report made in 1863 to legislature of Massachusetts. 106 pages; 20 plates. Edited by C. H. Hitchcock.

[CRUCIAL POINTS IN THE GEOLOGY OF THE LAKE SUPERIOR REGION. No. 7.]

A RATIONAL VIEW OF THE KEWEENAWAN.

By N. H. WINCHELL, Minneapolis, Minn.

The following further difficulties stand in the way of the Wisconsin idea of the separateness of the horizontal Lake Superior sandstones from the tilted.

1. There is no permanent petrographic distinction between them. The red shales and red sandstones, which are said to prevail in the tilted beds, are found in great volume in the lower portion of the horizontal beds. This may be seen in consulting the sections of the horizontal beds recorded by the Minnesota survey,* and by the descriptions of Mr. Sweet in volume III of the Wisconsin report, as well as by those of the eastern sandstone for many miles east of Keweenaw point by C. Rominger.

2. The tilted beds are sometimes horizontal or nearly so, and the horizontal beds are sometimes tilted at high angles.†

3. The top of the Keweenawan sandstones has never been observed.

4. The bottom of the overlying sandstones has never been observed except where by regional subsidence it is non-conformable upon the tilted traps or the older crystallines.

5. In various places the horizontal sandstones, and even some of the higher associated magnesian limestones, have been seen non-conformable on the traps of the lower portion of the Keweenawan, indicating a progressive submergence after the tilting of the traps.

6. The non-conformable contact which is assumed to have taken place between the base of the horizontal sandstones and the Keweenawan tilted sandstones has never been observed.

7. The whole region in which this question centers is one of disturbance and eruptive action. Ever since some of the horizontal sandstones were deposited there have been such move-

*N. H. WINCHELL, Tenth Minnesota report, pp. 30-34, 1881.

†SWEET, Trans. Wis. Acad. Sci., vol. III, p. 46. IRVING, in Am. Jour. Sci., (3), vol. VIII, July, 1874, p. 50, describes briefly horizontal red sandstones and shale on Silver creek, but in Copper Bearing Rocks of Lake Superior, Mon. V, U. S. Geol. Survey, he includes these in his upper member of tho Keweenawan. See plate XXII. See also p. 411, where Irving speaks of the "comparative flatness of the northward dip."

BROOKS, Geol. Sur. of Mich., vol. I, p. 185, 1873.

At nearly all the points where the horizontal sandstone lies non-conformably upon the traps it is locally highly tilted away from the traps.

ments that the sandstones are broken and thrust in various attitudes in their immediate relations with the traps.

8. The shortest observed interval between the horizontal sandstones and the tilted sandstones, within which such non-conformity must occur, if it exist at all, is four miles, viz., between Montreal river and Clinton point, both in Wisconsin.

9. If it were to be affirmed that there is no such non-conformable contact between these sandstones, the statement could not be disproved by any known facts.

10. If the statement were to be made that the upper part of the Keweenawan sandstones passes conformably into the horizontal, as represented in figure 1, in all places where they are in contact, excepting only a slow subsidence of the whole region, bringing the later horizontal sandstones unconformably over wider and wider areas of formerly tilted rocks, such statement could not be disproved by any known facts, but would be in harmony with all that is known of these formations.

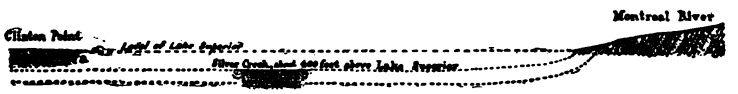


FIGURE 1. Structural relations of the sandstones at Clinton point, Montreal river and Silver creek. This collocation of these outcrops is warranted by Prof. Irving's final mapping of the sandstones on Silver creek, in Ashland, Co., Wis. (Copper-bearing Rocks, plate XXII.)

Up to the date of Maj. Brooks' work in the Lake Superior region it had generally been considered that the trap rocks of the copper-bearing series, and the sandstones with which they are associated, whether interstratified or otherwise, constituted essentially one formation, all the non-conformities that were observed being local phenomena such as an epoch of eruptive disturbance would be subject to. When, however, the non-conformable underlying trap rocks at Taylor's Falls (i. e. St. Croix falls) were traced from that point to their connection with the trap rocks in the northern part of Wisconsin and Michigan, it was thought at once that the evidence bore out the conclusion that the upper sandstone was a formation distinct from the copper-bearing series. The upper sandstone being considered, at Taylor's Falls, as of Potsdam age, it was appropriate, with that view of the evidence, to give a new name to the trap rocks. When later it was found that a great thickness of sandstone is sometimes seen tilted con-

formably with the traps, and must therefore belong with them, it became necessary to divide the sandstone between the Potsdam age and the age of the Keweenawan. When, still later, it was found that the overlying strata at Taylor's Falls are not of the age of the sandstones which, in the Lake Superior basin proper, overlie unconformably the trap rocks, but are considerably higher, and actually consist, in part, of the magnesian limestones which are well known as parts of the Calciferous of New York state, it became apparent that the basal beds of the supposed non-conformable upper sandstones had nowhere been seen, but that the Taylor's Falls locality could not be taken to show a wide-spread non-conformity between two separate formations, but rather implied that after the time of the eruptives there had been, in the Lake Superior region, a subsidence which at first brought some of the lower sandstones upon the tilted traps non-conformably, and at a later date also brought some of the higher sandstones and some of the magnesian limestones non-conformably upon the same beds in other places. These facts have been brought to light since the new name was applied, and they should be given their proper significance, since they disturb the grand conclusion as to the distinctness of the eruptive age from the Potsdam. Without the knowledge of this progressive submergence after the epoch of eruption, and without the knowledge of the later crustal movements which, after the deposition of the horizontal sandstones, have disturbed them on a grand scale in Douglass Co., Wisconsin, and along the Keweenaw peninsula, it was a very reasonable conclusion that the Keweenawan in all its parts is non-conformable below all the "horizontal sandstones." That would be the first interpretation that would be put upon the facts as seen by Brooks and Irving. It seems now, however, that the violent tilting and shattering which the Keweenawan strata have suffered may in part be of a date as late as after the horizontal sandstones, and in part due to local volcanic or other dynamic disturbance during the progress of the eruptive epoch, and, finally, in part due to a grand crustal movement which has advanced since Archean time tending to give both these and all earlier strata a synclinal dip toward lake Superior.

The only point, however, which it is intended to insist on, at this place, is the lack of sufficient evidence to show a general

erosion interval between the Keweenawan sandstones and the horizontal sandstones—such an interval as would allow the lapse of the time involved in the Taconic, or Lower Cambrian, while the region of lake Superior was dry land. During such an interval the upper Keweenawan sandstones would have been entirely swept away, or so hardened that they would show marked lithological contrasts with the "horizontal sandstones."

What has now been said relating to the Keweenawan is mainly of the nature of destructive and controversial criticism of the views which are set forth in Bulletins 81 and 86, of the United States Geological Survey, touching the nature and structural relations of those rocks. It sometimes becomes necessary to enter upon wholesale re-examination of the evidences on which hypotheses are founded. It is proposed now to construct the Keweenawan in the light of some newly discovered facts, and to indicate its stratigraphic place.

The eruptive rocks which have been included in Michigan, Wisconsin and Minnesota in the Keweenawan consist of two widely different series, of widely separated ages. This statement is based on facts observed in Minnesota, mostly not yet published in detail, but it is believed to be equally applicable in Wisconsin and Michigan. The brief letter of Dr. U. S. Grant published* in June, 1894, expresses the key to this separation, viz., the Animikie was upturned by eruptive disturbance, and changed to quartz-porphyries and probably augite-syenites prior to the Keweenawan. Along with this disturbance there issued from greater depths in the earth great quantities of gabbro and allied eruptives. This may be fully understood by consulting the important work of Dr. W. S. Bayley on Pigeon point,† without further specification. The eruptive red rocks which Bayley has described can be traced westwardly to Brulé lake, and still further west and to Duluth. They are not of Keweenawan age, though so mapped and described by Irving. They are everywhere associated with modified conditions of the Animikie and with coarsely crystalline basic rock. Indeed, the great gabbro, or anorthosyte,

*American Geologist, vol. xiii, p, 437, 1894.

†The eruptive and sedimentary rocks of Pigeon point, Minn., and their contact phenomena. Bulletin 109, U. S. Geol. Surv., 1893.

masses are believed to be wholly of this age. The writer has discussed the pre-Keweenawan age of this gabbro quite fully, based on Lawson's report and vivid illustrations from photographs, in Bulletin 8, of the Minnesota survey, and the results of later field work in northeastern Minnesota have only served to supply details entirely consistent with this general distinction. The basal conglomerate at Grand Portage island contains pebbles from these eruptive rocks as well as from the hardened clastics of the Animikie adjacent. The great gabbro dikes which cut the Animikie about Grand Portage bay, rising abruptly, as in Mt. Josephine and Hat point, from three hundred to a thousand feet above lake Superior, extend from Pigeon point characteristically across the Indian reservation and to Brulé lake. At this point the slates are hardened into a "black rock," or are rendered vesicular, but are distinguishable as members of the Animikie. The details of the extension of these eruptives to Duluth cannot be given here. Suffice it to say that as a group they appear on the lake shore at many places, and apparently flowed as lava sheets. They constitute the felsytes at Grand Marais, and at Baptism river and near Duluth. They easily furnish pebbles on the lake beach. This group seems to constitute the most of the shore on the north side of the lake, in Minnesota, leaving much less of the Keweenawan proper than has been supposed. The later Keweenawan eruptives invaded these eruptives in the form of laccolites and of dikes. The gabbro is frequently cut by them. The beautiful display of these later Keweneewan basic eruptives at the red rock point east of the "Eastern palisades" may be mentioned. The trap sheets that pass about and underlie the "Great palisades" are of later Keweenawan, the palisades themselves being pre-Keweenawan. The red islands at and east of Beaver bay are pre-Keweenawan. At Beaver bay and eastward from there the later traps hold many pieces of the earlier eruptives, both basic and acid, which they have derived from them in flowing along. These have been noted by several geologists.

The reader is referred to a fuller discussion of this question in the introduction to Bulletin VIII, of the Minnesota survey, where also is presented evidence of a similar separation in Wisconsin and Michigan.

After the Animikie revolution was a long erosion interval. This interval is emphasized by the siliceous conglomerates that have already been referred to—first at the base of Grand Portage island, second, in the valley of the St. Louis river, and third, west of Agogebic lake, as described recently by Van Hise.* This conglomerate we are disposed to consider as pre-Keweenawan, notwithstanding the argument of Van Hise that it is post-Keweenawan. Its readiness to disintegrate on exposure to the atmosphere is perhaps its strongest evidence of post-Keweenawan age. So far as observed all pre-Keweenawan conglomerates are much indurated.

In addition to these localities Sweet has described it in T. 32, R. 6 W., Wisconsin, on the Chippewa river, but without apprehending its age, except that he found it underlying a massive quartzyte. The conglomerate here reaches 300 feet in thickness.† It has been fully described by the Wisconsin Geological Survey.‡ This conglomerate and the overlying quartzyte have been found in Minnesota associated as in Wisconsin. At New Ulm this conglomerate lies on a coarse red granite and has a thickness exposed of about 25 feet. As a conglomerate this formation is not known further southwest, but as a quartzyte it appears conspicuously in Cottonwood county, where it forms a long characteristic ridge. It reappears in Pipestone county, and is well known at Sioux Falls, in South Dakota. Red felsytes, probably connected with it, have been described by S. W. Beyer,§ and certain diabases apparently cutting it in South Dakota have been described by G. E. Culver and W. H. Hobbs.‖

This red quartzyte has had various names, and has been assigned to various ages. The authors of the Wisconsin geological report, 1873-1879, referred it to the Huronian, and they have since so considered it, though, later, Van Hise has charitably covered the whole question with the convenient noncommittal term *Algonkian*. The writer originally, in 1872,

*The Penokee Iron-bearing series of Michigan and Wisconsin, Mon. XIX, U. S. Geol. Sur., p. 461.

†E. T. SWEET, Notes on the Geology of Northern Wisconsin. Wisconsin Acad. Sci. and Arts, vol. III, p. 45.

‡Vol. IV, p. 575.

§Iowa Geological Survey, vol. I, 1892, p. 165.

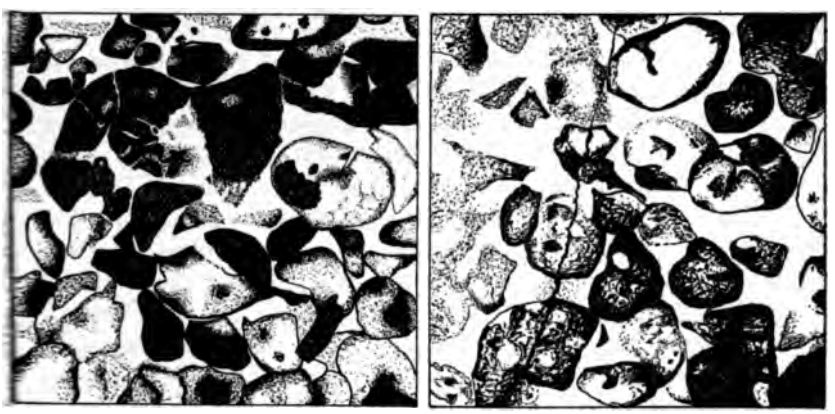
‖Wisconsin Acad. Sciences, vol. VIII, p. 206.

referred it to the Potsdam, and at a later date described *Paradoxides barberi* and *Lingula calumet* from the red pipestone clay at Pipestone, Minn., which is a layer embraced in it.

Probably there is no one who would call in question the fact that this conglomerate and quartzyte are earlier than the Keweenawan eruptive age. This is owing to the metamorphism and upheaval to which it has been subjected, and to a general alliance which it shows in other ways with the older rocks. That its age is post Animikie, i. e., post Upper Huronian, is shown by its contents. The writer once made, in company with Prof. R. D. Irving, a collection of the various sorts of rolled pebbles that occur in this conglomerate at New Ulm. One of the most common kinds is a sort of jasper, probably of the same variety as seen by Mr. Sweet in the conglomerate on the Chippewa river. On making thin sections of these jasper pebbles they are found to be very characteristically from the taconyte beds of the Mesabi range, or from the parallel strata of the Penokee range. It may be thought by those who have not carefully studied the crystalline rocks, that a *jasper* is not a very sure guide to the age of the conglomerate in which it may occur as a pebble. But a little consideration will show, in this case, that there is no mistake. This is a peculiar jasper —so peculiar that it has received the special name *taconyte*.* Several thin sections are illustrated in Bulletin X, Minnesota survey, by Mr. J. E. Spurr (plates V, VI, VII and VIII) who considers this taconyte one of the stages of transformation of the ores of the Mesabi range from glauconite to hematite. Prof. Van Hise has illustrated others from the Penokee range in his discussion of the Penokee iron-bearing rocks (plates XXVI, XXVII and XXIX) but he gives a different explanation of their origin. Setting aside entirely the question of their origin it is plain that they are peculiar to the upper iron-bearing member of the Lake Superior region. Such jasper pebbles of course might be found in any later fragmental rock, through the transportations which the formations undergo as débris from older to newer strata. But if it be characteristic in its indigenous form of a certain horizon it will never be found in a conglomerate at a lower stratigraphic horizon. This is the case with this curious jasper. There are

*H. V. Winchell, Twentieth Minnesota report, p. 124, 1893.

banded jaspers in the older strata, and they are repeated in the Mesabi rocks, owing to the recurrence of the same causes and conditions in the time of the Mesabi iron ore, or owing to the existence of conglomerates in the Mesabi rocks derived from the older rocks, but there are no taconyte jaspers in the older rocks; at least, during all the time that the members of the Minnesota survey have studied the older rocks none have been found, and they have not been reported from the lower strata by any other geologist. Dr. U. S. Grant, who detected this taconyte in this conglomerate, has kindly made the accompanying drawings which show these taconyte grains magnified about thirty diameters.



2 3

FIGURE 2 (Minn. Geol. Sur. No. 852 B) and FIGURE 3 (Minn. Geol. Sur. No. 852C). Thin sections of taconyte pebbles in the conglomerate at Courtland, Nicollet Co., Minn. The black, both solid and dots, represents hematite. The white, both between and in the granules, is very finely crystalline silica. The iron ore thus not only coats the surface of the granules, but penetrates into them and sometimes makes up whole granules. Magnified about thirty diameters.

This seems to prove that the Sioux quartzyte, the New Ulm quartzyte, the Barraboo quartzyte and the Barron County quartzytes are of the same age, since they have always been linked under one grouping by all who have classified them. Being post-Mesabi and post-Penokee and pre-Keweenawan the question next arises, where are they to be found in the Penokee region? *They are below the Keweenawan diabases.* It is a fact, which has not attracted much attention, that there is a considerable quartzyte and conglomerate below the Keweenawan diabases in the Penokee district. The writer first, so

far as known, reported this in the Penokee district, and referred it to the base of the Keweenawan.* But a very slight exposure was seen near Bessemer in 1885. Mr. W. G. La Rue, of Barraboo, Wis., gave more definite information concerning it. North from the Colby mine near the bluffs of the Keweenawan range, which there are plainly visible rising as a series of hills within a mile or less of the village (Bessemer), he was employed to explore for ore. Under the Keweenawan diabases, or gabbro, he found a quartzyte and a sandstone, the two differing only in induration, both consisting of crystalline quartz. He shafted under the quartzyte in a conglomerate of iron ore, and after a time he found that the conglomerate turned almost at a right angle toward the north. He did not ascertain what was under the conglomerate, but he found the quartzyte and sandstone together had a thickness of at least 235 feet. This was in the S. W. ¼, N. E. ¼, sec. 10, 47-16, Michigan.

Besides the points mentioned in Minnesota two others may be referred to. In 1879 the writer noted a red quartzyte, whose appearance reminded him of the New Ulm rock, on the upper waters of the Temperance river, near the Mesabi divide. This is much re-crystallized, however, so far as specimens collected show, but some of the thin sections consist almost wholly of quartz. This quartzyte range occurs just south of the anorthosyte and the red-rock belt, and north of the principal Keweenawan ridge. Again, in Bulletin V, of the Minnesota geological survey, will be found the record of a deep well drilled at Short Line Park, in the St. Louis valley west of Duluth. This well is located about 200 feet above the river, on the flank of the "gabbro" range, which here, however, consists of a more or less diabasic, amygdaloidal rock. The drill struck at the depth of 463 feet, a quartzose rock, or grit, which proved to develope at a greater depth into a siliceous conglomerate which was described as *pudding-stone*, plainly the same as that which is at the river side about a mile further down the valley, already referred to as probably being pre-Keweenawan. This rock was struck below 230 feet of the so-called gabbro of that region, and developed a thickness of 67 feet.

With this it is safe to say that [illegible] *the Animikie*

*Sixteenth Minnesota report, pp. xxvi. Eighteenth report, pp. 42-43.

there was a long erosion interval. It may be that the great felsyte-pebble conglomerate at the mouth of the Montreal river will prove yet to be the basal conglomerate of the Keweenawan proper. It is evident that it remains yet to trace out this quartzyte and conglomerate carefully in Wisconsin and Michigan, as well as in Minnesota, for that they have an important place and significance seems unquestionable. It will doubtless be found, in the main, along the base of the precipitous side of the Keweenawan ridge, in Minnesota on the north side of the Keweenawan hills and in Wisconsin on the south side of the same range. Owing to the induration which it and the overlying sandstone have suffered by the action of the Keweenawan traps, it is very persistent and has escaped the destruction which otherwise would have befallen it. In volume, character and hardness it is comparable to the conglomerate and associated quartzyte described by the writer at Cascade, Mich., and at Ishpeming.* At the former of these points it lies on the Taconic ore horizon of the Animikie and contains the peculiar taconyte pebbles, but at the latter it is non-conformable on the lower iron horizon, viz., that of the Vermilion range of Minnesota, and is made up locally of the débris of the Archean. The horizon of the conglomerate itself, however, is the same at both points, as it is traceable continuously between them. It has been supposed to belong in the base of the Taconic horizon (Upper Huronian) but evidently it is later and, according to the foregoing classification, belongs to the base of the Keweenawan. Other conglomerates in the region, much less dense, though non-conformable on the Taconic iron horizon, may belong higher. The mere fact that a conglomerate contains taconyte does not prove it to belong at the base of the Keweenawan. It only proves that it cannot be older than the base of the Keweenawan.

There is a curious anomaly to which Van Hise has called attention in the Penokee region, viz., the "cherty carbonate" is intermittent, although it is a part of the Penokee series. A conglomeratic quartzyte lies non-conformably upon it. It may be that in some places he has mistaken the basal conglomerate of the Keweenawan for a conglomerate of the Penokee series. In case the structural relations do not sufficiently

*Sixteenth Minnesota report, pp. 43-48, 1887.

determine the stratigraphic place of such a transgressive conglomerate, an inspection of the pebbles would decide. If any of them consist of the peculiar taconyte, the conglomerate must be later than the Penokee series.

Prof. Van Hise has kindly submitted for examination three specimens taken from this conglomerate, viz., Nos. 9418, 9420 and 9449 (mentioned on pp. 167 and 169, Mon. XIX, U. S. Geol. Survey). They are from secs. 14 and 15, of T. 47-45 W., Michigan. The first two of these show no evident taconyte pebbles but numerous angular and sub-angular pieces of cherty silica, in a dark gray or greenish matrix. No. 9449 is similarly composed, but coarser and lighter colored. There is near the center of this specimen a large light-gray, impure, cherty mass or fragment whose texture and composition are not unlike some parts of the taconyte seen in the Mesabi rocks of Minnesota, but there are no certain or characteristic globular spots in any of the pebbles marking the conglomerate as post-Penokee. The conglomerate at the Palms mine likewise shows, in one specimen belonging to the Minnesota survey, nothing but débris from the Archean.

On the north shore of lake Superior this conglomerate leaves the Minnesota shore at Grand Portage island. It reappears at the west end of Isle Royale, where it has a large exposure, and is overlain by red sandstone.* It is largely exposed northward from Siskiwit bay, having a strong dip toward the south. The northern rim of this island is composed of a dike or series of dikes of the type of the Grand Portage and Pigeon Point dikes. The shore is high and precipitous and the water very deep, caused by the perpendicularity of an immense Animikie dike. The overlying Keweenawan conglomerate consists of felsitic material of Animikie source, also of some of the hardened grits of the Wauswaugoning quartzyte. Thus Isle Royale is divisible between the Animikie and the Keweenawan, the larger portion of it belonging to the latter. The strike of these Keweenawan beds is such that they cannot reach the Lake Superior shore again until many miles east of Thunder bay and Nipigon. In addition to this, they differ so remarkably from the fragmental strata, which at Thunder bay and Black bay have been considered the base of the Keweenawan

*Tenth Minnesota report, p. 48.

by Irving and Van Hise, that they cannot be parallelized with them, although they directly overlie non-conformably the same Animikie beds.

Mr. Thomas Macfarlane concluded from his section of the Keweenawan at cape Mamainse, on the eastern shore of lake Superior*, that a sandstone of greater age than the bedded traps is a reasonable supposition, from the evidence, and that it perhaps belongs to the lower group of the upper copper-bearing series. He seems, however, in deference to the opinion of Sir William Logan, to have finally decided that it is a part of the non-conformable overlying sandstones which extend to Sault Ste. Marie.

The Keweenawan eruptive age, following the accumulation of this conglomerate and quartzyte, separated the Paradoxides horizon from the Dicellocephalus horizon. The former is represented by *Paradoxides barberi* of the pipestone clay, and the latter by the fossils of the St. Croix beds of the Mississippi valley. It is evident from the non-discovery of fossils that during the accumulation of the Lake Superior sandstone, which seems to be conformable below the St. Croix sandstones and dolomytes, the ocean's waters were not yet sufficiently settled to allow of the existence of animal life, at least in the Lake Superior region. There is no evidence that the ocean was driven out at once after the eruptions.

The Olenellus horizon is separated from the Paradoxides horizon by the disturbance that closed the Animikie. The absence of Olenellus, and of nearly all fossils, from the Animikie strata of course stands yet in the way of the full establishment of this proposition. But there is every reason to expect that the proper fauna will yet be discovered in these beds. Indeed, it is not wholly wanting. Mr. G. F. Matthew has described a Taonurus-like impression from the Animikie rocks of the north shore of lake Superior, discovered by Dr. Selwyn, and has named it *Medusichnites.*† This is similar to several other forms found by Mr. Matthew in the St. John group of New Brunswick and illustrated by him in the same volume.

Reference should also be made to the indication of foraminiferal fossils in the glauconite sand from which the iron ores

*Geological Survey of Canada, Report for 1866, p. 136.

†Trans. Roy. Soc. Canada, vol. VIII, sec. IV, p. 143, 1890. Originally described in the Am. Jour. Sci., Feb., 1890, as *Taonichnites.*

of the Mesabi region are derived. Although as yet no identifiable organic forms have been detected in the few microscopic slides that have been made, their presence in the rock originally is so strongly indicated by all the attendant circumstances that Mr. Spurr has included it as probable amongst his final conclusions.* This discovery is also in line with the late announcement by Mr. W. D. Matthew of the discovery of many foraminiferal forms associated with a large amount of iron in the St. John group, in New Brunswick,† which points to the Lower Cambrian age of the upper iron-bearing rocks of the Mesabi region.

THE MENTOR BEDS: A CENTRAL KANSAS TERRANE OF THE COMANCHE SERIES.

By F. W. Cragin, Colorado Springs, Colo.

The *Mentor beds*, named from a small station in Saline county, Kansas, within the area of their outcrop, are a terrane of variegated, earthy-textured marine shales, with intercalated beds of brown sandstone, resting in part conformably upon the Kiowa shales and in part unconformably upon the drab and purple-red laminated shales and impure limestones of the Permian, and succeeded above by the more heavily arenaceous fresh-water sediments of the Dakota. They were formerly considered by all geologists as constituting a part of the Dakota group, but are now known to belong to the upper part of the Comanche series.

The Mentor beds occur typically in Saline county, to whose area their outcrops contribute more than those of any other formation, and nearly all of that part over which the Dakota-sandstone-topped Iron Cap mound, North Pole mound, Soldier Cap mound, and Smoky Hill buttes stand sentinel and indicate the comparatively recent erosion of the Dakota. They occur in the southeastern quarter of Ellsworth county also, extending thence eastward across the northern part of McPherson county, to and beyond the noted double eminence,

*American Geologist, vol xiii, p. 335.
Bulletin X, Minnesota Geological Survey, 1894.
†Trans. N. Y. Acad. Sci., vol. xii, pp. 108-120, 1893.

which, strewn with huge rectangular blocks of quartzytic sandstone, is known as Battle hill. They are supposed to appear to some extent also in Rice, Marion, and Dickinson counties, though their presence there still lacks confirmation, and in Marion and Dickinson they must be limited to the northern and southern parts of the counties respectively.

The shales of the Mentor beds are chiefly argillaceous,but they contain a greater or less admixture of sand, to which, as soft sandstones, they locally give place in certain horizons. They apparently contain some lime also, partly in the condition of sulphate. Being little consolidated, they weather into gentle slopes and broad, low, rounded eminences scarcely worthy the name of hills, and present few conspicuous outcrops. Such outcrops of the shales as do occur present themselves either as limited, more or less steep-faced banks of marly-appearing clay, of white, ferruginous-yellow, red, or blue color, or parti-colored with two or more of these. Their coloring seems to be the result of the variable distribution of oxide, peroxide, and sulphates of iron.

The sandstone of the Mentor beds occurs in thin, local strata. While these are of slight consequence judged by the space they occupy, they are nevertheless of great stratigraphic importance, since it is from these alone that our knowledge of the geological age of the Mentor terrane has been derived. So soft is this sandstone that its natural outcrops rarely present themselves as integral ledges, but commonly as slopes scattered with lumps and slabs of sandstone, representing the hardest and most durable parts of a vanished bed; but occasionally appears a ledge that is considered sufficiently hard and uniform to be quarried, yielding a rather soft and poor quality of building-stone. Some quarries of this sort, belonging to the Mentor beds, may be seen in the district between Bavaria and Soldier Cap mound.

The thickness of the Mentor beds varies greatly, since that portion of the terrane that rests directly upon the Permian lies unconformably upon the latter and presents considerable differences in the elevation of its base. It probably nowhere greatly exceeds fifty or sixty feet.

The fauna of the Mentor beds, so far as at present known, is included in the following list:

Ostrea franklini, Coq.
Ostrea quadruplicata, Shum.
Anomia sp.
Avicula salinaënsis, White.
Gervillea mudgeana, White.
Modiola pedernalis, Roem.
Barbatia parallela, Mk
Trigonarca salinaënsis, Mk.
Nucula catherina, Crag.
Yoldia microdonta, Mk.
Trigonia clavigera, Crag.
Crassatellina oblonga, Mk.
Lucina (?) sp.
Cardium kansasense, Mk.
Protocardium texanum, Con.
Corbicula (?) nucalis, Mk.
Corbicula subtrigonalis, Mk.
Cyprimeria texana, Roem.
Tellina subscitula, Mk.
Arcopagella mactroides, Mk.
Leptosolen conradi, Mk.
Mactra siouxensis, M. & H.
Margarita mudgeana, Mk.
Turritella seriatim-granulata, R.
Sphenodiscus pedernalis, Von B.

About twenty-five years ago Prof. B. F. Mudge collected a number of marine fossils from sandstone of the Mentor beds (then referred to the Dakota) twelve miles southwest of Salina. Of the sixteen molluscan forms reported as thus collected by him, fourteen were described by Meek in the Fourth Annual Report and in volume IX of the Final Report of the Hayden U. S. Geological Survey of the Territories, all of these being illustrated in the latter volume; and two were described and figured by White in volume IX of the Proceedings of the U. S. National Museum and in the Twelfth Annual Report of the Hayden Survey.

The forms described from this terrane by these authors are as follows:

Ostrea sp.
Avicula salinaënsis, White.
Gervillea mudgeana, White.
Barbatia parallela, Mk.
Trigonarca salinaënsis, Mk.
Yoldia microdonta, Mk.
Crassatellina oblonga, Mk.
Corbicula (?) nucalis, Mk.
Corbicula subtrigonalis, Mk.
Cardium kansasense, Mk.
Protocardium salinaënse, Mk.
Tellina subscitula, Mk.
Arcopagella mactroides, Mk.
Leptosolen conradi, Mk.
Margarita mudgeana, Mk.
Turritella kansasensis, Mk.

The *Turritella kansasensis* of this list is a synonym of *T. seriatim-granulata*, Roemer, which occurs in all or nearly all of the terranes of the middle and upper Comanche. *Modiola pedernalis*, *Cyprimeria texana* and *Sphenodiscus pedernalis* of the general faunal list are likewise common to the middle and upper Comanche. *Protocardium salinaënse*, Meek, is a synonym of *P. texanum*, Con., a species of the Denison beds and of the Kiowa shales. The specimens of this species figured by Meek are young examples; but the Mentor shales yield large

examples of the typical form so common in the Denison beds and in the Kiowa shales. The *Cardium kansasense* is a common fossil of the Kiowa shales but has not been reported from the Denison beds. *Ostrea franklini* occurs in profusion in the Kiowa shales and less abundantly in the Denison beds; while the *O. quadruplicata*, abundant in the Denison beds, occurs only in the upper part of the Kiowa shales, and that rather sparingly. *Trigonia clavigera* is common in the Marietta beds of the Denison and in the Kiowa. In his recent article on "The Choctaw and Grayson terranes of the Arietina" (published April 5, 1895, in Colorado College Studies, vol. 5*) the writer has noted the occurrence of the *Yoldia microdonta* in the Pawpaw clays of the Denison beds. It is probable that *Margaritana mudgeana*, Meek, should be added to the list of species common to the Mentor beds and the Kiowa shales, as the writer's *M. marcouana* is closely related to it and is likely to prove to be synonymous. The revolving carinæ on the shell are represented as plain in the former and are apparently crenulated or granulated in the latter species; but this supposed difference may be due to a difference in the state of preservation of the specimens examined.

The Mentor beds are thus seen to be characterized by a fauna related to that of the Denison beds and still more closely to that of the Kiowa shales. Their fauna is, in fact, especially related to that of the upper part of the latter.

The stratigraphic relation to the Kiowa shales is also close. While the Mentor beds generally rest upon the Permian in Saline county, they rest in part upon the Kiowa shales further southward, as shown by the occurrence beneath them of black shales amongst some of whose fossils, submitted to the writer from a few miles west of Lindsborg by Prof. J. A. Udden, are *Modiola stonewallensis*, nob., and *Sphenodiscus pedernalis*, Roem.; but whether they are to be considered as overlying all of the Kiowa or only a lower part of it, and whether or not they merge southward into the upper part of the Kiowa, are questions that remain still unanswered.

*As the date of the papers published in this volume has been called in question, the writer wishes here to state that, owing to circumstances beyond his control, this "Fifth Annual Publication" was erroneously dated "1894." Being a delayed volume, due to appear in 1894, it should have been inscribed, "For 1894," and the date of publication, 1895, should have been repeated at the foot of the title page.

THE LARVAL STAGES OF TRILOBITES.

By CHARLES E. BEECHER, New Haven, Conn.

(Plates VIII—X.)

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I. INTRODUCTION.

It is now generally known that the youngest stages of trilobites found as fossils are minute ovate or discoid bodies, not more than one millimetre in length, in which the head portion greatly predominates. Altogether they present very little likeness to the adult form, to which, however, they are traceable through a longer or shorter series of modifications.

Since Barrande[2] first demonstrated the metamorphoses of trilobites, in 1849, similar observations have been made upon a number of different genera by Ford,[22] Walcott,[34, 35, 36] Matthew,[26, 27, 28] Salter,[32] Callaway,[13] and the writer.[4, 5, 7] The general facts in the ontogeny have thus become well established and the main features of the larval form are fairly well understood.

Before the recognition of the progressive transformation undergone by trilobites in their development, it was the custom to apply a name to each variation in the number of thoracic segments and in other features of the test. The most notable example of this is seen in the trilobite now commonly known as *Sao hirsuta* Barrande. It was shown by Barrande[3] that Corda[17] had given no less than ten generic and eighteen specific names to different stages in the growth of this species alone.

The changes taking place in the growth of an individual are chiefly: the elongation of the body through the gradual addition of the free thoracic segments; the translation of the eyes, when present; the modifications in the axis of the glabella; the growth of the free-cheeks; and the final assumption of the mature specific characters of pygidium and ornamentation.

In the present paper the larval stages of several species are described and illustrated for the first time, and a review is under-

taken of all the known early larval stages thus far described. This work would have no special interest in itself were it not for the fact, that, with our present understanding of trilobite morphology, it is possible to reach some conclusions of general importance, which have a direct bearing on the significance and interpretation of several of the leading features of the trilobite carapace, and incidentally upon the structure and relations of the nauplius of the higher Crustacea.

II. The Protaspis.

Barrande[3] recognized four orders of development in the trilobites, as follows:

		Types.
I.	Head predominating, incomplete. Thorax nothing or rudimentary. Pygidium nothing.	*Sao hirsuta.*
II.	Head distinct, incomplete. Thorax nothing. Pygidium distinct, incomplete.	*Trinucleus ornatus*, and all *Agnostus.*
III.	Head complete. Thorax distinct, incomplete. Pygidium distinct, incomplete.	*Arethusina konincki.*
IV.	Head complete. Thorax complete. Pygidium distinct, incomplete.	*Dalmanites hausmanni.*

A study of these groups shows at once that they form a progressive series in which the first alone is primitive. The others are more advanced stages of development, as shown by the larger size of the individuals, and their having characters which appear successively in the ontogeny of a species belonging to the first order of development. To attain the stage which is represented by actual specimens, they must have passed through earlier stages, which as yet have not been found. Furthermore, it is evident that Barrande did not consider the orders after the first as primitive, and characteristic of the genera cited, for, in some remarks under the third order, he says[3]: "Il est très-vraisemblable, que la plupart des Trilobites de cette section, si ce n'est tous, devront être un jour transférés dans la première, par suite de la dècouverte probable d'embryons sans segmens thoracique."

The geological conditions necessary for the fossilization of the minute larval forms of trilobites are such, that only in comparatively rare instances are any of the immature stages preserved. Larval specimens are doubtless often overlooked or neglected by collectors, but generally the sediments are too

coarse for the preservation of these small and delicate organisms. In certain horizons and rocks, however, such remains are quite abundant, and complete ontological series may be obtained. Yet, it is not strange that series of equal completeness have not been found in all Paleozoic horizons.

The abbreviated or accelerated development of many of the higher Crustacea has resulted in pushing the typical free-swimming, larval nauplius so far forward in the ontogeny that this stage is either eliminated or passed through while the animal is still within the egg, so that when hatched it is much advanced. Although the trilobites show distinct evidence of accelerated development through the earlier inheritance of certain characters which will be taken up later, yet it is not believed that the normal series or periods of transformation were to any degree disturbed, since both the simplest and most primitive genera whose ontogeny is known and the most highly specialized forms agree in having a common early larval type. This would be expected from their great antiquity, their comparatively generalized and uniform structure, and from the fact that no sessile, attached, parasitic, land, or fresh-water species are known. These conditions by introducing new elements into the ontogeny would tend to modify or abbreviate it in various ways, especially among the higher genera.

Before discussing any of the various philosophical and theoretical problems involved in an attempt to correlate the larval forms of Crustacea, a brief consideration of the known facts relating to the larvæ of trilobites will be presented.

Minute spherical or ovoid fossils associated with trilobites have been described as possible trilobite eggs, by Barrande[3] and Walcott,[33] but nothing is known, of course, of the embryonic stages of the animals themselves. The smallest and most primitive organisms which have been detected, and traced by means of series of specimens through successive changes into adult trilobites, are, as stated above, little discoid or ovate bodies not more than one millimeter in length, as shown on plates VIII and IX. It is fair to assume that we have here a general exhibition of trilobite larval stages, since the ten species represented are from various geological horizons, belonging to the Cambrian, Ordovician and Silurian sediments, with

Devonian types, and showing the simple as well as the highly specialized forms.

All the facts in the ontogeny of trilobites point to one type of larval structure. This is even more noticeable than among recent Crustacea, in which the nauplius is considered as the characteristic larval form. It is desirable to give a name to this early larval type apparently so characteristic of all trilobites, and among different genera varying only in features of secondary importance. This stage may therefore be called the *protaspis* (*πρῶτος, primus; ἀσπὶς, scutum*).

The principal characters of the protaspis are the following: Dorsal shield minute, varying in observed species from .4 to 1 mm. in length; circular or ovoid in form; axis distinct, more or less strongly annulated; head portion predominating; glabella with five annulations; abdominal portion usually less than one-third the whole length of the shield, axis with from one to several annulations; pleural portion smooth or grooved; eyes when present anterior, marginal or submarginal; free-cheeks when present very narrow, marginal.

Several moults took place during this stage before the complete separation of the pygidium or the introduction of thoracic segments. When such moults are recognized, they may be considered as early, middle and late protaspis stages, and designated respectively as anaprotaspis, metaprotaspis and paraprotaspis. They introduced various changes, such as the stronger annulation of the axis, the beginning of the free-cheeks, and the growth of the pygidial portion from the introduction of new appendages and segments as indicated by additional grooves on the axis and pleura. Similar ecdyses occur during the nauplius stage of many living Crustacea before a decided transformation is brought about. Certain of these later stages have received a distinctive name, and are called the metanauplius.

It is believed that the protaspis is homologous with the nauplius or metanauplius of the higher Crustacea. Most of the reasons for this belief will appear later in the present paper; some which may be stated now are as follows:

(1) The size of the protaspis does not differ greatly from that of many nauplii, and represents as large an animal as could be hatched from the bodies considered as the eggs of trilobites.

(2) Some of the sediments carefully examined by the writer could preserve smaller larval trilobites were such originally present and provided with a chitinous test, as shown by the abundance of minute ostracodes, and the perfection of detail in these and other fossils.

(3) The protaspis can be shown to be structurally closely related to the nauplius, and in a more marked degree possesses some characters required in the theoretical crustacean ancestor.

III. Review of Larval Stages of Trilobites.

Matthew[27, 28] has carefully described several early larval (protaspis) stages of trilobites from the Cambrian rocks of New Brunswick, which are very simple and primitive, and will be noticed first.

Solenopleura robbi Hartt; plate VIII, figure 1; from the Cambrian of New Brunswick; after Matthew.[27] This larva is very minute and circular in outline; the glabella is obscurely annulated and extends to the anterior margin, where it is expanded; the neck ring is the only one well defined; the abdominal portion is less than one-third the whole length, and is limited by a slight transverse furrow; no traces of eyes or free-cheeks discernible.

Liostracus onangondianus Hartt; plate VIII, figure 2; from the Cambrian of New Brunswick; after Matthew.[27] This form is similar to the preceding, though larger, and with the glabella more rapidly expanding in front. The neck segment is the only one which is distinct.

It should be mentioned that most of the larval specimens here described and figured are preserved in fine shales and slates, as casts of the interior of the dorsal shield, so that some features are not as emphatic as on the exterior of the test. When well preserved, the axis always shows the typical five annulations on the cephalon.

Ptychoparia linnarssoni Walcott; plate VIII, figures 3 and 4; from the Cambrian of New Brunswick; after Matthew.[28] The earliest stage is slightly more elongate than the preceding forms. The axis is narrow, expanding in front and obscurely annulated, five annulations belonging to the cephalon, and one to the pygidium, which is very short and separated from the cephalon by a distinct groove.

The second stage (figure 4) is decidedly more elongate; the axis is more distinctly annulated; the occipital pleura defined; and the pygidium is larger and has an additional segment.

Ptychoparia kingi Meek; plate VIII, figures 5, 6 and 7; from the Cambrian of Nevada and Utah. Figure 5 represents a cast of the protaspis, and shows a defined occipital ring, with the axis slightly expanded and undefined in front; pygidium truncate behind. Figure 6, which is referred to a later stage (metaprotaspis) of the same species, shows the inception of several characters that have not as yet appeared in the previous larvæ. The axis is very strongly annulated; the anterior lobe is nearly as long as the four posterior annulations of the cephalon, and on each side there is a furrow representing the eye-line of the adult; the free-cheeks are present as narrow marginal plates, including the genal spines; the pygidium shows two segments separated by a furrow.

An adult *Ptychoparia kingi* is shown in figure 7 and may be taken as representing the sum of the changes passed through in the development of larvæ like the preceding, belonging to the genera *Solenopleura*, *Liostracus* and *Ptychoparia*. The introduction and growth of the segments of the thorax are perhaps the most marked changes, but other points of importance to be noted are: the comparatively smaller size of the cephalon and its transverse form; the limitation and recession of the glabella, which is now rounded in front, and only extends about two-thirds the length of the cephalon; the growth of the eyes and free-cheeks at the expense of the fixed-cheeks; the increased segmentation of the abdomen, shown in the axial and pleural grooves on the pygidium.

Sao hirsuta Barrande; plate VIII, figures 8, 9, 10 and 11; from the Cambrian of Bohemia; after Barrande.[3] The specimens of this species are preserved as casts, and several of the features are therefore somewhat subdued. The earliest or anaprotaspis stage, represented in figure 8, is quite as primitive in most respects as any of the preceding. It is circular in outline, the annulations of the axis are distinctly shown only in the neck segment and pygidial portion, and the eye-line is present. In figure 9 of the metaprotaspis, quite an advance is seen in the development of the free-cheeks and the more pronounced annulation of the glabella, together with pleural grooves from

the neck segment and those of the pygidium. The next stage (figure 10) probably represents the close of the protaspis stage (paraprotaspis) and the inception of the nepionic condition, when the cephalon and pygidium are distinct and before the development of the free thoracic segments.

In considering the changes necessarily passed through by these larvæ previous to attaining their adult characters (figure 11) the most notable, aside from increase in size and addition of the sixteen thoracic segments, are: the appearance and translation of the eyes *pari passu* with the growth of the free-cheeks; the growth of the border in front of the glabella, which now narrows anteriorly, and terminates about one-third the length of the cephalon within the margin; the less distinct annulation of the glabella; and the development of the spines and tubercles ornamenting the test.

Triarthrus becki Green; plate VIII, figures 12, 13, and 14; from the Ordovician, Utica slate, near Rome, N. Y. A larval form of this species was figured by the writer[5] in 1893. At this time, the eye-line was confused with the anterior annulation of the axis, making the cephalon appear to have six instead of five annulations. A recent examination of a large number of specimens shows that five is the invariable number, as here represented. Two protaspidian stages of this species have been noticed, differing chiefly in the size of the pygidium. Both agree in showing a strongly annulated axis, not expanded in front and terminating some distance within the margin. From the first annulation, a slightly elevated ridge on each side indicates the eye-line, and extends to the marginal eye-lobe. The adult form (figure 14) shows in addition to several characters noted in the previous species, the nearly complete loss of the two anterior annulations of the glabella; the disappearance of the eye-line; and the development of a row of nodes along the axis, from the neck segment to the proximal segment of the pygidium.

Acidaspis tuberculata Conrad; plate IX, figures 1, 2 and 3; from the Lower Helderberg group, Albany county, New York.[4] Several of these remarkable larvæ have been found perfectly silicified in a limestone from which they have been freed by etching. In general form, they resemble the second larval stage of *Sao* (plate VIII, figure 9), but the pygidium is shorter

and the glabella does not expand and terminate in the anterior margin. No eye-line is present, but the eye-lobes may be seen a little within the margin. The glabella has the characteristic number of annulations; margin provided with a row of denticles; genal angles extended into spines; pygidium with four spines.

The adult condition (figure 3) shows that the eyes have moved inwards and backwards to near the neck segment. The glabella has lost its annulations and is broken up into a median lobe with two smaller ones on each side, while the neck ring is projected into a spine. The changes noted here are much more profound than in any of the preceding genera, since *Acidaspis* is one of the most highly specialized of trilobites in its glabellar structure and elaborate ornamentation. The protaspis, too, partakes of this specialization, and, although the general form of the shield and the annulation of the axis are as primitive as in *Triarthrus*, yet the characteristic spinosity of the genus appears even at this early stage and is a marked instance of acceleration of development.

Arges consanguineus Clarke; plate IX, figure 4; from the Lower Helderberg group, Albany county, New York. A single larval form of this type has been found and at first was provisionally referred to *Phaëthonides*.[4] The recent publication by Clarke,[14] of *Arges consanguineus* from the same horizon, and a comparison of the larva with the description and with considerable additional material, renders it now possible to determine definitely the relations of this interesting form. As the main details of structure in *Acidaspis* and *Arges* are so similar, the transformations undergone by the larva are much alike in each case. The young *Arges* likewise shows the same acceleration in the development of the spines and surface ornamentation, and the retention of the primitive features of the glabella. The specimen seen in figure 4 represents a late larval stage (paraprotaspis), as shown by the transverse form of the cephalon and the large size of the pygidium.

Proëtus parviusculus Hall; plate IX, figures 5, 6 and 7; Utica slate, near Rome, New York. Two larval stages of this species have been found. The younger (figure 5) is smooth, broadly ovate, .72 mm. long, and widest in front; axis distinctly annulated, cylindrical on the cephalon, tapering on the

pygidium; eyes nearly transverse to the axis, very large and prominent, situated on the anterior margin, separated only by the axis. The specimen represented in figure 6 is in the paraprotaspis stage, and measures .96 mm. in length. It shows an advance over the other in its size, its larger pygidium with grooved pleura, and the beginning of the recession of the eyes.

The adult of this small species is shown in outline enlarged two diameters, in figure 7. The principal changes from the larva which should be noticed are: the loss of the four anterior annulations of the glabella, the neck segment being the only one wholly defined, although the basal lobes represent remnants of the next anterior; the translation of the eyes backward as far as the pleura of the neck segment, and the change from a transverse to a parallel position with respect to the axis.

In the original description of this species,[23] no mention was made of fine undulating striæ ornamenting the entire dorsal surface of the test, nor of the basal lobes of the glabella. Both these features are present in the type specimen, which is from Cincinnati, Ohio, as well as in all the specimens from the Utica slate, near Rome, New York. With these additional characters, the species is very closely related to *Proëtus decorus* Barrande.

Dalmanites socialis Barrande; plate IX, figures 8-11; from the Ordovician of Bohemia; after Barrande.[3] A nearly complete series of the growth stages of this species is given by Barrande. The earliest, or anaprotaspis, stage found (figure 8) exhibits an outline and axis similar to *Acidaspis*. The eyes are quite large and situated, as in the same stage of *Proëtus*, transverse to the axis, on the anterior border. Genal angles present, but in this case not produced by the free-cheeks as in *Sao* and *Ptychoparia;* glabella strongly annulated, increasing in diameter anteriorly, although not expanding at the frontal margin as in *Sao*, etc. In the two following stages (figures 9, 10), the pygidium increases in size, and the pleura are defined. To reach maturity (figure 11), eleven segments are developed in the thorax, the glabella becomes more prominently developed in front, but the five annulations are maintained. The eyes have travelled in and back as far as the third head segment, and their longer axes have swung around

into a position parallel with the axial line, as in *Proëtus*. The pygidium has added many new segments, and the extremity is prolonged into a spine.

Before proceeding further in the discussion of the protaspis, it is necessary to notice a number of forms of young trilobites which have heretofore been referred to the embryonic and larval stages, but which are now believed to belong to stages later than the protaspis.

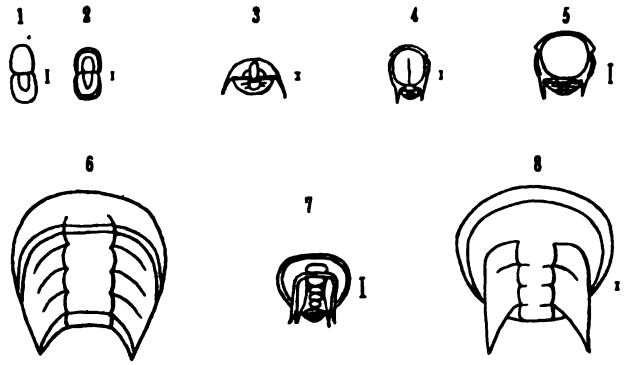


FIGURE 1. *Agnostus nudus* Beyr.; after Barrande.
FIGURE 2. *Agnostus rex* Barr.; after Barrande.
FIGURE 3. *Trinucleus ornatus* Sternb.; after Barrande.
FIGURE 4. *Hydrocephalus saturnoides* Barr.; after Barrande.
FIGURE 5. *Hydrocephalus carens* Barr.; after Barrande.
FIGURE 6. *Olenellus* (*Mesonacis*) *asaphoides* Emmons; Ford collection; original. x 30.
FIGURE 7. *Olenellus* (*Mesonacis*) *asaphoides* Emmons: after Ford.
FIGURE 8. *Olenellus* (*Mesonacis*) *asaphoides* Emmons; after Walcott.

Besides the truly elementary forms described by Barrande and already noticed (*Sao hirsuta* and *Dalmanites socialis*), there are others which he referred to his second, third and fourth orders of development.[3] Among these *Agnostus* may be taken first. The youngest forms of *Agnostus nudus* and *A. rex* (figures 1, 2) measure respectively 2 and 1.3 mm. in length, and the adults 13 and 15 mm. The earliest stages of the genera shown on plates VIII and IX measure less than 1 mm., while the adults are more than 25 mm., with the exception of *Proëtus parviusculus*, which is seldom more than 10 mm. long, though this species has a protaspis .72 mm. in length. The cephalon and pygidium of the youngest known *Agnostus* are quite separate and distinct, which is not the case with the typical protaspis stage. It therefore seems probable that on account of the comparatively large size and advanced struc-

ture of the youngest stages observed, the elementary forms of this genus are as yet unknown, and possibly the extreme tenuity of the test in the protaspis has prevented their preservation. In the same way the young of *Trinucleus* (figure 3) show a separate cephalon and pygidium, and the specimens are in a much more advanced stage of development than the protaspis of *Proëtus*, shown on plate IX, figure 5. An evidence of age is furnished, also, in the transverse shape of the head, which, in typical elementary forms, is longer than wide, instead of wider than long.

The youngest specimens of *Arethusina koninckí*, figured by Barrande,[3] are 2 mm. or upwards in length and have seven or more free thoracic segments, with the cephalon wider than long. The facts of ontogeny show that younger stages must be admitted in which the number of segments diminishes to nothing, continuing down to a form agreeing with the protaspis of other genera.

It has already been suggested[4] that the species described by Barrande[3] under the generic name of *Hydrocephalus* are probably the young of *Paradoxides*. This conclusion receives further support from the undoubted young of *Olenellus*, a related genus, which in its immature stages bears a strong resemblance to *Hydrocephalus*. The youngest examples of the latter have a distinct pygidium, a well-developed cephalon, and large eye-lobes at the sides of the glabella, as in adult forms. Free-cheeks were evidently present though not generally preserved. See figures 4 and 5.

The young of *Olenellus asaphoides*, described and illustrated by Ford[22] and Walcott,[35, 36] also present a number of features considerably in advance of a typical protaspis. The immature characters are mainly the large size of the cephalon and the distinct annulation of the axis. The post-protaspidian characters are the distinct and separate pygidium, the adult position of the eyes, and the apparently well-developed free-cheeks. In figure 7, after Ford,[22] the outer pair of spines belongs to the free-cheeks, the other pair being formed by the pleural extensions of the glabella, which were called the interocular spines. See also figures 6 and 8.

The young specimen of *Ptychoparia monile* Salter sp., figured and noticed by Callaway,[13] is 1.5 mm. in length, and

agrees, as far as can be determined without seeing the original, with what is known of other species of the same genus. It probably belongs to a stage later than the protaspis.

Matthew[26] has carefully described some small cephala of *Ctenocephalus* (*Hartella*) *matthewi* and *Conocoryphe* (*Bailiella*) *baileyi*, from the Cambrian of New Brunswick. The fact of their being separate cephala, transverse in form, and from 2 to 3 mm. in length, is sufficient to show that they do not represent the youngest stages of these species.

The immature examples of *Agnostus*, *Trinuclus*, *Arethusina*, *Paradoxides*, *Olenellus*, *Ctenocephalus* and *Conocoryphe*, here briefly noticed are of great interest in a study of the ontogeny of the various species to which they pertain. In the present paper, however, it is intended chiefly to establish the primary larval characters of the trilobites, and therefore only the earliest stages are considered. Under the genera just mentioned, the writer has endeavored to show that as yet their ontogeny cannot be traced as far back as the stage which has been defined as the *protaspis*. Therefore, any general notions of first larval forms must at present be based on the genera *Solenopleura*, *Liostracus*, *Ptychoparia*, *Sao*, *Triarthrus*, *Acidaspis*, *Proëtus* and *Dalmanites*.

IV. Analysis of Variations in Trilobite Larvæ.

After taking a general survey of the earliest known larval stages of trilobites figured on plates VIII, IX, it is evident that an accurate and detailed description of any one would not apply to any other except in certain broad characters. To formulate a definition of the protaspis applicable to all, as has been done previously (p. 169), it is necessary to neglect or eliminate some rather striking characters which should now be mentioned. A few features thus omitted are considered as very primitive larval characters, while others are modifications introduced in higher or later genera through the operation of the law of earlier inheritance.

From the best evidence now obtainable, the eyes have migrated from the ventral side, first forward to the margin and then backward over the cephalon to their adult position, thus agreeing with Bernard's conclusions.[12] Therefore, the most primitive larvæ should present no evidence of eyes on the dorsal shield, and naturally there would be no free-

cheeks visible. Just such conditions are satisfied in the youngest larva of *Ptychoparia*, *Solenopleura* and *Liostracus*, which are the most primitive genera whose protaspis is known. The eye-line is present in the later larval and adolescent stages of these genera, and persists to the adult condition. In *Sao* it has been pushed forward to the earliest protaspis, and is also found in the two known larval stages of *Triarthrus*. *Sao* retains the eye-line throughout life, but in *Triarthrus* the adult has no traces of it, and none of the higher and later genera studied has an eye-line at any stage of development. Matthew has considered this feature as especially characteristic of most of the Cambrian genera, and now it is further shown to be a character first appearing in the later larval stages of certain genera (*Ptychoparia*, etc.), next in the larval stages (*Sao*), then disappearing from adult stages (*Triarthrus*), and finally pushed out of the ontogeny altogether (*Acidaspis*, *Dalmanites*, etc.). The eyes are visible on the margin of the dorsal shield after the paraprotaspis stage, later than the eye-line in *Ptychoparia*, *Solenopleura*, *Liostracus*, *Sao* and *Triarthrus;* but in the other genera through acceleration they are present in all the protaspis stages, and persist to the mature, or ephebic, condition, moving in from the margin to near the sides of the glabella.

The changes in the glabella are equally important and interesting. Throughout the larval stages, the axis of the cephalon is five-segmented or annulated, indicating the presence of as many paired appendages on the ventral side. In its simplest and most primitive state, it expands in front, joining and forming the anterior margin of the head (larval *Ptychoparia*, *Sao*). During later growth it becomes rounded in front and terminates within the margin. In higher genera through acceleration it is rounded and well-defined in front even in the earliest larval stages and often ends within the margin (larval *Triarthrus*, *Acidaspis*). From these common types of simple, pentamerous glabellæ, all the diverse forms among adult individuals of various genera have been derived, through changes affecting any or all of the lobes. The modifications usually take place in the anterior lobes first, and gradually involve the others, though rarely disturbing the neck segment which is the most persistent of all. Six lobes are occasion-

ally found in the glabellæ of some species. They do not indicate an additional pair of limbs, for the extra lobe is produced (*a*) by division of the anterior lobe through the greater or less extent of the eye-line across the axis, as in *Olenellus*, *Paradoxides* and *Ogygia*; or (*b*) by the marked development of muscular fulcra, which are supposed to be connected with the hypostoma.

The next structures not especially noticeable in all stages of the protaspis are the free-cheeks, which usually manifest themselves in the meta- or paraprotaspis stages, though sometimes even later. Since they bear the visual areas of the eyes, their appearance on the dorsal shield is practically simultaneous with these organs; and before the eyes have travelled over the margin, the free-cheeks must be wholly ventral in position. They are very narrow when first discernable (plate VIII, figures 6, 9 and 10), and in *Pytchoparia*, *Sao*, etc., include the genal angles, but in *Dalmanites* they extend only a short distance below the eyes.

The remaining features of the protaspis which here require notice are the pleural furrows and the pygidium. The pleura from the anterior segments of the glabella are occasionally shown, as in the young of *Olenellus* (figure 6), but usually the pleura of the neck segment are the first and only ones to be distinguished on the cephalon, the others being so intimately coalesced as to lose all traces of their individuality. This makes the cranidium, or head shield, exclusive of the free-cheeks, consist of the fused lateral extensions or pleura of the head segments, as already noticed by Bernard.[12] The possible pleural or segmental nature of the free-cheeks will be noticed later.

The distinct pleura of the pygidium appear soon after the anaprotaspis stage, and in some genera (*Sao*, *Dalmanites*) are even more marked than in the adult state, much resembling separate segments. The growth of the pygidium is very considerable through the protaspis stages. At first it is less than one-third the length of the dorsal shield, but by the successive addition of segments, it soon becomes nearly one-half as long. In some genera it is completed before the appearance of the free thoracic segments, though usually new segments are added during the adolescence of the animal.

A number of genera present adult characters, which agree closely with some of the larval features noticed in this section, and are important in a phylogenetic study of the trilobites. The main features of the cephalon in the simple protaspis forms of *Solenopleura*, *Liostracus* and *Ptychoparia*, are retained to maturity in such genera as *Carausia* and *Acontheus*, which have the glabella expanded in front, joining and forming the anterior margin. They are also without eyes or eye-line. *Ctenocephalus* retains the archaic glabella nearly to maturity, and likewise shows eye-lines and the beginnings of the free-cheeks (larval *Sao*). *Conocoryphe* and *Ptychoparia* are still further advanced in having the glabella rounded in front, and terminated within the margin (larva of *Triarthrus*). These facts and others of a similar nature show that there are characters appearing in the adults of later and higher genera, which successively make their appearance in the protaspis stage, sometimes to the exclusion or modification of structures present in the most primitive larva. Thus the larvæ of *Dalmanites* or *Proëtus*, with their prominent eyes, and glabella distinctly terminated and rounded in front, have characters which do not appear in the larval stages of ancient genera, but which may appear in their adult stages. Evidently such modifications have been acquired by the action of the law of earlier inheritance, or tachygenesis. Altogether it seems that we have represented on plates VIII and IX a progressive series of first larval stages in exact correlation with adult forms, the latter also constituting a progressive series, structurally and geologically.

A summary of the features added to the dorsal shield of the anaprotaspis stage of acceleration during the evolution of the class, from the simpler forms of Cambrian times to the later and more highly differentiated *Dalmanites*, *Proëtus* and *Acidaspis*, would include: the free-cheeks; the eyes; the more strongly lobed glabella, rounded in front; the transient eye-line; the genal angles; and the ornaments of the test.

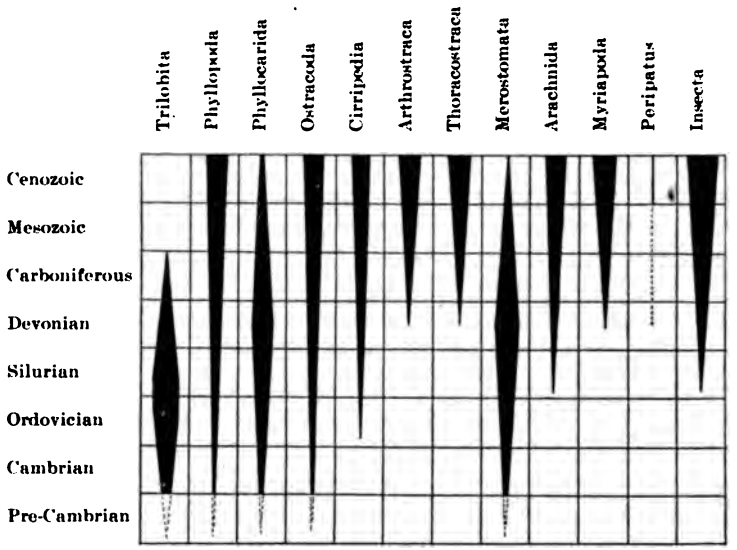
These additions, as may be seen by reference to plates VIII and IX, considerably complicate and modify the primitive protaspis, but, as previously mentioned, it does not lose any of its essential structures. Besides, it is possible to trace the origin and significance of the acquired characters, and thus to assign to each its true value.

V. Antiquity of the Trilobites.

The superlative age of the trilobites has been generally recognized, and is too well known to require more than a passing notice. Even in the earliest Cambrian, they bear evidence of great antiquity in their diversified form, their larval modifications, and their polymerous head and caudal shield, all of which features show that trilobite phylogeny must reach far back into pre-Cambrian times.

Not only are the smallest species found in the Cambrian (*Agnostus*), but also many of the largest (*Paradoxides*). There is a great range of variation in the number of free thoracic segments, varying from two in *Agnostus* to twenty in *Paradoxides*. The pygidium likewise shows extreme variation of from two to upwards of ten ankylosed segments. The eyes may be absent as in *Agnostus* and *Microdiscus*, or very large as in *Paradoxides*, though both in this respect and in the number of somites, free or fused, the Cambrian genera are exceeded in later deposits. In ornamentation and spiniform processes, the Cambrian species show considerable development though not as great as others since that time. However, the wide variations they do present in this particular indicates differentiation and specialization considerably removed from the beginning of the trilobite phylum.

The acquisition of distinct larval stages could only have been reached through a long series of changes in ancestral forms. The composition of the cephalon and caudal shield indicates a derivation from some primitive form, probably annelidan, in which, through adaptation to special requirements, certain polar segments became fused, forming very distinct terminal body regions. Furthermore, the tribolites are the only large division of the Arthropoda which has become extinct. The Merostomata and Phyllocarida, culminated a little later, though still represented by living species, but all the other divisions apparently have continued to increase since their inception during Paleozoic time. The only known arthropod contemporaries of the trilobites in the Cambrian are the Merostomata, Ostracoda, Phyllopoda, and Phyllocarida, all of the higher forms apparently having developed since that time. A more graphic view of the geological range and distribution of the arthropods is represented in the following table:



Having thus far reviewed the features of the primitive protaspis and some of the characters it acquired through earlier inheritance, together with the comparative age of the different groups of arthropods, it must be conceded, that, in interpreting crustacean phylogeny from the facts of ontogeny, the trilobites, so far as they show structure, are entitled to first place. Moreover, since the appendages are quite fully known and from them the trilobite proves to be a most generalized and primitive crustacean, still greater reliance can be placed on deductions based upon a study of this type. The recent discoveries of the antennæ and the exact details of trilobite structure, together with the larval homologies here made and the concordance of trilobites with the theoretical original crustacean leave almost no doubt as to their true crustacean affinities. Woodward,[37] from another point of view, reaches the same opinion by saying: "The trilobita, being certainly amongst the earliest forms of crustacea with which we are acquainted, cannot be removed from that class without destroying its ancestral record."

VI. Restoration of the Protaspis.

At first thought, the attempt to reconstruct the ventral side of the trilobite protaspis may seem a little hazardous or premature, but a careful consideration of all the data leads the writer to undertake this with some confidence.

The genus *Triarthrus* is taken for the basis of this restoration, as it is to-day the best known of all the trilobites, and its ventral structure has been ascertained to a degree of perfection of detail which compares favorably with many of the recent crustaceans.[6, 7, 8, 9] The writer has studied the structure of many adult and immature specimens some of them not more than 5 mm. in length, so that fortunately the appendages are known at many stages of growth. Especially are the young and rudimentary limbs near the extremity of the pygidium in adolescent individuals of considerable morphological interest, for they agree closely with the phyllopodiform trunk appendages in the metanauplius of *Apus*, and protozoëa of *Euphausia*, or in a general way, with the still more rudimentary trunk limbs in the nauplius stages of these and other forms.

It has been definitely ascertained that the cephalon in trilobites bears five pairs of jointed appendages or limbs.[9] In larval or immature specimens, and in adults in which the glabella retains its primitive structure, this number is indicated on the dorsal shield by the five lobes or annulations of the glabella, including the neck ring. These may therefore be taken as representing, in so far, the original segmentation of the head, and agree with what is generally accepted as the primitive structure in modern true Crustacea. The head portion of the protaspis clearly shows this pentasomitic structure, and evidently carried a corresponding number of paired limbs on the ventral side. It has also been demonstrated that the annulations on the axis of the pygidium correspond to the number of paired limbs beneath, exclusive, of course, of the anal segment. Here, too, it is possible to tell from the pygidial portion of the protaspis the number of limbs present during life. The protaspis of *Triarthrus*, represented in plate VIII, figure 13, on this basis had five pairs of limbs attached to the head portion and two pairs to the pygidium.

Next, as to the composition and form of these elementary protaspis limbs, it is safe to assume that the anterior pair, corresponding to the antennules, must be uniramous since they are so during all the young and adult stages observed, and since this form is common to all nauplius stages of modern Crustacea, and is recognized as primitive and elementary for the class. There is apparently a greater similarity in the

larval antennules than between any other appendages, and as *Apus* and *Euphausia* have these in a very generalized form, they are taken as types of the first pair of limbs of the trilobite protaspis, as shown in plate X, figure 1 (1). It should be noted, too, that the antennules of the trilobites arise from the sides of the upper lip or hypostoma, as in the nauplius.

The other head appendages are typically branched, though in many of the recent Crustacea they lose this character after the larval stages. Especially is this true of the third pair of limbs, which become modified into the mandibles. In trilobites the primitive biramous structure of the head limbs persists to adult stages, occurring also in limbs of all the posterior segments where they become more and more phyllopodiform.[8] In the restoration of the protaspis it seems only necessary to append this archaic type of limb to each segment, agreeing as it does in form and structure with the rudimentary limbs of older stages and with the nauplius and metanauplius stages of *Apus*.

It cannot be doubted that the protaspis had five pairs of limbs on the head portion and one or more on the pygidium, and although these are the main points necessary to prove the argument in the next section, on the nauplius, yet it seems perfectly warrantable and better for graphic purposes to attach the required number of elementary limbs to the ventral side of the protaspis, as represented in plate X, figure 1.

There are other organs and structural details occurring in the nauplius and in adult trilobites, which deserve recognition in a restoration of the protaspis stage. First among these is the labrum, or upper lip. Nowhere is this plate so well developed and so striking a ventral feature as among the trilobites. There can be no hesitation, therefore, in accepting this as characteristic of the protaspis.

The trilobites and most recent crustaceans have a metastoma, or lower lip. This is already developed in the nauplius stage of some Crustacea, as *Euphausia* and *Peneus*, and probably represents an early larval character. It usually appears as a median plate divided into two small plates, or lappets, on each side of the median line, posterior to the mouth, and is thus represented in the restored protaspis. As it occurs on a segment bearing also a pair of legs and has no separate neuromere, it cannot well be considered as representing a somite.

An anal opening is found in most nauplii, especially in those of the non-parasitic Crustacea, and in those in which this stage is normal and free-swimming. The protaspis, as representing a free-swimming larval stage of trilobites, therefore, probably possessed an anal opening.

The only character represented in the restoration which is accepted purely from analogy is the median unpaired eye. This organ is almost universally present in the nauplius, and is regarded as a very primitive character wherever found.

The next and last structures to be noticed are the free-cheeks and the beginnings of the paired eyes, as shown in plate X, figure 1 (*g*, *oc*). Their existence has already been indicated in the descriptions and observations of the protaspis and its derived characters, and need not be repeated here. Apparently the nauplius presents nothing homologous, unless possibly the frontal sensory organs of *Apus*, *Balanus*, *Peneus*, etc., may be taken as such. The paired eyes and frontal sensory organs are close together and seem to have some intimate connection, for, as the paired eyes develop, the latter dwindle and disappear. Likewise in the trilobites the free-cheeks bear the visual areas, and may be almost wholly converted into eyes as in *Eglina* (*Cyclopyge*).

The greater or less separation of the cerebral ganglia in the chætopods and in some of the lower crustacea leads to the idea that the free-cheeks in trilobites are the pleura of an oculiferous head segment, which otherwise is lost. If the hypostoma is homologous with the annelid prostomium, as urged by Bernard[11], then the free-cheeks may be considered as representing the second procephalic segment, which is the number required on the supposition that each neuromere corresponds to a somite. There is a separate neuromere to each mesodermic metamere posterior to the head, and from analogy we should expect that each neuromere in the head would represent an original segment, especially as it can be demonstrated that the head is composed of consolidated or fused segments (Kingsley[24]).

Having thus shown the probable ventral structure of the protaspis, we are prepared to make some general observations on the larval type of modern Crustacea known as the *Nauplius*. Before doing this it is well to emphasize again that there is

very positive evidence, amounting virtually to certainty, that the protaspis had five pairs of limbs attached to the cephalic portion, behind which was an abdominal portion containing the formative elements out of which all the posterior somites and appendages were developed.

VII. The Crustacean Nauplius.

The name *Nauplius* was first used by O. F. Müller[29] to designate a minute crustacean believed to represent an adult animal. Afterwards it was found to be a larval stage of *Cyclops*, but because it agreed in structure with the larvæ of many other Crustacea the name was retained for that type of larval form and is now in general use. Primarily it is supposed to represent the first free-swimming stage after the escape of the animal from the egg. However, many species are quite fully developed when leaving the egg, and undergo comparatively slight subsequent metamorphoses, and in these and other species there may be developed in the egg an embryo having some of the characters of the nauplius. Therefore, the term is also applied to all cases where a certain assemblage of nauplian characters occurs in the development of any crustacean. Thus it may be considered as a stage of development not restricted to a definite period of ontogeny.

The adult *Apus* possesses so many nauplian features, and in its development passes through such simple metamorphoses, that it has been aptly considered by Bernard[11] as a nauplius grown to maturity. Balfour[1] also states that the chief point of interest in the development of *Apus* "is the fact of the primitive Nauplius form becoming gradually converted without any special metamorphoses into the adult condition."* This form, together with the nauplii of other crustaceans and the study of the larval and adult characters of the trilobites, ought to afford definite knowledge of the characters possessed by the ancestral forms of the Crusatcea.

Before farther examining the nauplius it may be well to state the characters, which, on the grounds of comparative anatomy and phylogeny, are believed to represent the primitive adult crustacean. It will be seen that, in many respects, the trilobite

*The adult *Apus* properly has five pairs of cephalic limbs. A sixth pair of appendages has been correlated as maxillipedes, though from their innervation they seem to be metastomic and homologous with the chilaria of *Limulus*.

recalls this type, but, as already suggested, is removed some distance from the prototype, although in itself a most primitive crustacean. Lang[25] gives a very comprehensive description of the racial form, as follows: "The original Crustacean was an elongated animal, consisting of numerous and tolerably homonomous segments. The head segment was fused with the 4 subsequent trunk segments to form a cephalic region, and carried a median frontal eye, a pair of simple anterior antennæ, a second pair of biramose antennæ and 3 pairs of biramose oral limbs, which already served to some extent for taking food. From the posterior cephalic region proceeded an integumental fold which, as dorsal shield, covered a larger or smaller portion of the trunk. The trunk segments were each provided with one pair of biramose limbs. Besides the median eye there were 2 frontal sensory organs. The nervous system consisted of brain, œsophagael commissures and segmental ventral chord, with a double ganglion for each segment and pair of limbs. The heart was a long contractile dorsal vessel with numerous pairs of ostia segmentally arranged. In the racial form the sexes were separate, the male with a pair of testes, the female with a pair of ovaries, both with paired ducts emerging externally at the bases of a pair of trunk limbs. The excretory function was carried on by at least 2 pairs of glands, the anterior pair (antennal glands) emerging at the base of the second pair of antennæ, the posterior (shell glands) at the base of the second pair of maxillæ. The mid-gut possibly had segmentally arranged diverticula (hepatic invaginations)."

The characters ascribed to the typical nauplius have been selected mainly on the principle of general average. They do not satisfy the theoretical demands resulting from a comparative morphological study nor are they consistent with the accepted requirements of an ancestral type of the Crustacea. Claus[16] urges that the nauplius is a modified or secondary larval form, and the writer now hopes to farther substantiate this view, and partly to reconstruct the nauplius from internal evidence and from its more primitive representative, the protaspis of the trilobites.

The usual fetaures attributed to the nauplius are: three pairs of appendages, afterwards forming two pairs of antennæ

and the mandibles; the first pair is uniramous and sensory in function; the second and third pairs are biramous, swimming appendages; body usually unsegmented; anteriorly there is a single median eye, and a large labrum, or upper lip; an alimentray canal bent anteriorly, and ending in an anus near the posterior end of the body; a dorsal shield; the second pair of antennæ are innervated from a sub-œsophageal ganglion. Frontal sense organs and a rudimentary metastoma are sometimes present. The trunk and abdominal regions are not generally differentiated.

Balfour[1] remarks of the nauplius that: "In most instances it does not *exactly* conform to the above type, and the divergences are more considerable in the Phyllopods than in most other groups." This variation is indeed quite marked among nearly all the groups besides the phyllopods and furnishes the facts for the conclusion, that the hexapodous condition is not primitive.

On plate X are represented some of the leading types of nauplius structure, taken chiefly from the excellent compilation by Faxon.[2] Bearing in mind the typical and average characters of this larva, some of the variations will be briefly reviewed.

The nauplius of *Apus*, represented in plate X, figure 2, shows the rudiments of five trunk segments, which in a later stage (figure 3) develop phyllopodiform appendages belonging to sixth, seventh, and eighth pairs of limbs. They are the anterior trunk appendages and appear at a time when the fourth cephalic pair is a mere rudiment while the fifth is entirely undeveloped. The fourth and fifth pairs of head appendages evidently must have some existence, though undeveloped in the nauplius. The physical conditions of nauplius life probably do not require them, and they therefore remain for a time quiescent or undeveloped.

In figures 4, 5, 8, and 6, respectively, of *Branchipus*, *Artemia*, *Leptodora*, and *Limnaida*, the first pair of appendages becomes progressively shortened, until, in the last, they almost disappear. *Leptodora* (figure 8) and *Lepidurus* (figure 7) also have rudimentary trunk segments and appendages (*y*). Figures 9 and 10 of *Daphnia* and *Moina* (from summer eggs), show how rudimentary the nauplius appendages may become when this stage

is passed within the egg. Even a more marked reduction is exhibited in the embryos of *Palæmon* and *Astacus* (figures 25 and 26). *Cyclops* is a very normal form, though even here in a second nauplius stage (figure 12), a fourth pair of limbs is developed.

Examples have been cited showing the reduction and obsolescence of the anterior antennæ, or first pair of nauplius limbs, and some cases will now be cited in which the third pair also becomes reduced and rudimentary. *Achtheres* (figure 14) and *Mysis* (figure 22) afford instances of this variation. The former is of additional interest, as showing that the appendages from the fourth to the eighth, may be developed, while the third remains quiescent, and that the second pair, typically biramous, is here unbranched. Similarly, in *Mysis*, *Nebalia* (figure 19), and especially in *Cypris* (figure 18), the nauplius limbs are simple. The embryo of *Lucifer* (figure 24) and a late nauplius stage of *Euphausia* (figure 21) are also of moment, in showing the beginnings of the metastoma (*mt*) with the two maxillæ and first maxillipedes.

It appears from the foregoing facts, that enough has been shown to prove the marked variations in the number and state of development of the nauplius appendages, and to reach the conclusion, that potentially five pairs of cephalic appendages are present. The two posterior pairs are the ones usually not developed until after some of the trunk limbs appear. Very satisfactory explanations have been offered as to why the first three pairs have been selected by the larva, although it does not seem to have been recognized that the fourth and fifth have been more or less suppressed during the evolution of the class. Lang[25] accouuts for the three pairs of nauplian limbs by saying that: "In a young larva which, like the *Nauplius*, is hatched early from the egg, only a few of the organs most necessary for independent life and independent acquisition of food can be developed. The 3 most anterior pairs of limbs which serve for swimming may be described as such most necessary organs. The third pair perhaps belongs to this category, because as mouth parts, generally provided with masticatory processes, they serve not only witn the others for locomotion, but also for conducting food to the oral aperture."

Another point in favor of the original pentamerous composi-

tion of the cephalic portion of the nauplius or protonauplius is the dorsal shield which is present in many forms, and is considered (*vide* Bernard[11]) as a dorsal fold of the fifth segment. So that in reviewing the nauplius structures, we find here and there evidences of the entire series of head segments.

Now, since the protaspis fulfils the rquirements by having five well-developed cephalic segments, and is besides the oldest crustacean larva known, it is believed that, in so far, at least, it represents the primitive ancestral larval form for the class.

The nauplius, therefore, is to be considered as a derived larva modified by adaptation.

Other variations in the characters of the nauplius occur, but as they have clearly originated (*a*) from the parasitic habits of the adult, (*b*) from embryonic conditions, or (*c*) from earlier inheritance, they need not enter into consideration here. Such, for example, are (*a*) the absence of an intestine in *Sacculina*, (*b*) the absence of the median eye in *Daphnia* and *Moina*, and (*c*) the bivalve shell in *Cypris*. The larval stages of other, and especially later and higher groups of arthropods, offer more considerable differences and need not enter into this discussion, which is aimed chiefly to establish the genetic relationship between the protaspis of trilobites and the nauplius of recent Crustacea.

VIII. Summary.

Barrande first demonstrated the metamorphoses of trilobites in 1849, and recognized four orders of development, which are now shown to be stages of growth of a single larval form.

A common early larval form is recognized and called the *protaspis*.

The protaspis has a dorsal shield, a cephalic portion composed of five fused segments and a pygidial portion consisting of the anal segment with one or more fused segments.

The simplest protaspis stage is found in the Cambrian genera of trilobites. During later geological time it acquired additional characters by earlier inheritance and became modified, though retaining its pentamerous glabella and small abdominal portion.

Some of these acquired characters of the dorsal shield are the free-cheeks, the eyes, the eye-line, the genal angles and the ornaments of the test. The free-cheeks and eyes moved to the dorsum from the ventrum.

The history of the acquired characters is traced by means of comparisons between larval and adult trilobites, through paleozoic time, and a progressive series of larval forms established in exact correlation with adult forms, which themselves constitute a progressive series, chronologically and structurally.

The antiquity of trilobites is indicated by their remains in the oldest Paleozoic rocks, and especially by the fact that in the early Cambrian they are already much specialized and differentiated in number of genera. The age of the trilobite or crustacean phylum is further shown from the distinct larval stages of trilobites and their having a head and pygidium of consolidated segments.

Since the trilobites are among the oldest and most generalized of Crustacea, their ontogeny is of considerable importance in interpreting crustacean phylogeny.

The protaspis in its segmentation shows that the cephalon had five pairs of appendages as in the adult.

The crustacean nauplius is shown to be homologous with the protaspis and to have potentially five cephalic segments bearing appendages, which should therefore be taken as characteristic of a protonauplius.

The nauplius is a modified crustacean larva. The protaspis more nearly represents the primitive ancestral larval form for the class, and approximates the protonauplius.

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X. Explanation of Plates.

PLATE VIII.

FIGURE 1. *Solenopleura robbi* Hartt; after Matthew. Anaprotaspis stage; showing obscurely annulated axis. x30. St. John group, Cambrian, New Brunswick.

FIGURE 2. *Liostracus onangondianus* Hartt: after Matthew. Anaprotaspis stage: the neck lobe is the only one distinctly marked. x23. Cambrian, New Brunswick.

FIGURE 3. *Ptychoparia linnarssoni* Walcott: after Matthew. Anaprotaspis stage; axis slender, slightly annulated; pygidium defined by transverse furrow. x30. Cambrian, New Brunswick.

FIGURE 4. *Ptychoparia linnarssoni* Walcott: after Matthew. Protaspis representing a later moult than the preceding, and showing stronger annulations on the axis, with an additional one on the pygidium. x25. Cambrian, New Brunswick.

FIGURE 5. *Ptychoparia kingi* Meek. Anaprotaspis or early stage; showing obscurely defined characters, partly due to the fact that the specimen is a cast. x45. Cambrian, Nevada.

FIGURE 6. *Ptychoparia kingi* Meek. A later stage (metaprotaspis); showing the strongly annulated axis, the eye-line, the free-cheeks including the genal angles, and two segments on the pygidium. x45. Cambrian, Nevada.

FIGURE 7. *Ptychoparia kingi* Meek; after Walcott. An adult specimen. This and the other figures of adult individuals are represented in outline, with the free-cheeks shaded, to bring out more strongly the changes in the structure of the cephalon. x1_2. Cambrian, Utah.

FIGURE 8. *Sao hirsuta* Barrande; after Barrande. Anaprotaspis stage; showing obscurely the limits of the pygidium, the eye-line, and the nearly cylindrical glabellar axis, expanding on the frontal margin. This and the two following specimens are preserved as casts. x30. Cambrian, Bohemia.

FIGURE 9. *Sao hirsuta* Barrande: after Barrande. A later moult, probably near the end of the metaprotaspis stage: showing the annulated axis expanded in front: free-cheeks narrow and marginal: pygidium of four segments, with pleura distinctly marked and grooved. x30. Cambrian, Bohemia.

FIGURE 10. *Sao hirsuta* Barrande: after Barrande. A more advanced stage at or after the close of the paraprotaspis, in which the pygidium is complete, but before the first free thoracic segment is developed. x30. Cambrian, Bohemia.

FIGURE 11. *Sao hirsuta* Barrande. An adult individual combining the characters as shown in several of Barrande's figures of this species. x1_2. Cambrian, Bohemia.

FIGURE 12. *Triarthrus becki* Green. Anaprotaspis: showing the annulated axis, terminating before reaching the anterior margin: the eye-lines extending from the first segment to the marginal eye-lobes: pygidium defined by a slight groove, and including two segments of the axis. x45. Ordovician, Utica Slate, near Rome, New York.

FIGURE 13. *Triarthrus becki* Green. Protaspis at a later moult: showing slight increase in size and the addition of a segment to the pygidium. x45. Utica Slate near Rome, New York.

FIGURE 14. *Triarthrus becki* Green. An adult individual of this species. x1_2. Utica Slate, New York.

PLATE IX.

FIGURE 1. *Acidaspis tuberculata* Conrad. Anaprotaspis: showing denticulate margin and spines on cephalon: axis strongly annulated: eyes submarginal. x20. Lower Helderberg, Albany Co., New York.

FIGURE 2. The same: profile, slightly oblique. x20.

FIGURE 3. *Acidaspis tuberculata* Conrad. An adult individual, restored from fragments and an entire enrolled specimen. Natural size. Lower Helderberg, Albany Co., New York.

FIGURE 4. *Arges consanguineus* Clarke. Dorsal view of a larva at or after the close of the paraprotaspis stage: showing the form and ornamentation. x20. Lower Helderberg, Albany Co., New York.

FIGURE 5. *Proëtus parviusculus* Hall. Anaprotaspis: showing strongly annulated axis, with grove at each side: large prominent anterior eyes: pygidial pleura indicated by faint grooves. x45. Ordovician, Utica Slate, near Rome, New York.

FIGURE 6. *Proëtus parviusculus* Hall. A later moult, near the close of the paraprotaspis stage: showing the larger pygidium which, however, is still incomplete, and the slight backward movement of the eyes. The right side of the specimen is restored. x45. Ordovician, Utica Slate, near Rome, New York.

FIGURE 7. *Proëtus parviusculus* Hall. An adult individual. x2 Ordovician, Utica Slate, near Rome, New York.

FIGURE 8. *Dalmanites socialis* Barrande: after Barrande. Anaprotaspis stage: showing the large strongly annulated axis; the prominent anterior marginal eyes: mucronate genal angles: pygidium of three segments. x30.

FIGURE 9. *Dalmanites socialis* Barrande; after Barrande. Metaprotaspis stage; showing the stronger definition of the pleura of the pygidium. x30. Ordovician, Bohemia.

FIGURE 10. *Dalmanites socialis* Barrande; after Barrande. The specimen probably represents the close of the paraprotaspis stage, and shows four segments in the pygidium and the first evidence of the backward movement of the eyes, which now indent the margin. x30. Ordovician, Bohemia.

FIGURE 11. *Dalmanites socialis* Barrande; after Barrande. Outline of an adult individual. $x^1/_2$. Ordovician, Bohemia.

PLATE X.

The Roman numerals indicate the appendages in their consecutive order.

I, 1st pair of appendages, or antennules.

II, 2d pair of appendages, or antennæ.

III, 3d pair of appendages, or mandibles.

IV, V, etc., maxillæ, maxillipeds, swimming feet, etc.

Ocl, unpaired eye; *oc*, paired eyes; *lb*, labrum.

FIGURE 1. *Triarthrus becki*. A restoration of the ventral side of the protaspis stage in accordance with the best evidence at present attainable, as explained in the text. The VIth and the VIIth pairs of appendages belong to the abdomen, which is marked off by a transverse line; *mt*, metastoma; *g*, free-cheeks.

FIGURE 2. *Apus cancriformis*: after Claus (from Faxon). *Phyllopoda*. Nauplius larva, just hatched; ventral side. Behind the mandibles (III) are indications of five thoracic somites, *y*.

FIGURE 3. *Apus cancriformis*; after Claus (from Faxon). *Phyllopoda*. Second larval stage (metanauplius); ventral side. The second maxilla, V, is wanting; *f*, frontal sense organs.

FIGURE 4. *Branchipus stagnalis*; after Claus (from Packard). *Phyllopoda*. Nauplius stage.

FIGURE 5. *Artemia gracilis*; after Packard. *Phyllopoda*. Nauplius stage; showing obscure segmentation.

FIGURE 6. *Limnaida hermanni*; after Lereboullet (from Packard). *Phyllopoda*. Nauplius; dorsal side; first pair of appendages obsolescent; labrum, *lb*, greatly developed.

FIGURE 7. *Lepidurus productus*; after Brauer (from Bernard). *Phyllopoda*. Nauplius with obscure segmentation of the trunk, *y*.

FIGURE 8. *Leptodara hyalina*; after Sars (from Balfour and Bronn). *Phyllopoda, Cladocera*. Nauplius larva from winter egg; *y*, rudimentary feet.

FIGURE 9. *Daphnia longispina*; after Dohrn (from Claus). *Phyllopoda, Cladocera*. Nauplius stage of embryo, with rudimentary appendages.

FIGURE 10. *Moina rectirostris*; after Grobben (from Faxon). *Phyllopoda, Cladocera*. Embryo from the summer egg in the nauplius stage, developed in the brood-cavity of the parent; appendages rudimentary.

FIGURE 11. *Cyclops tenuicornis;* after Claus (from Balfour). *Copepoda, Natantia.* Nauplius, first stage. This and the next are the original forms described as *Nauplius*, by O. F. Müller, and believed at that time to be adult.

FIGURE 12. *Cyclops tenuicornis:* after Claus (from Balfour). *Copepoda, Natantia.* Nauplius, second stage; IV, maxilliæ.

FIGURE 13. *Cetochilus septentrionalis;* after Grobben (from Faxon). *Copepoda, Natantia.* Nauplius, just hatched; ventral view.

FIGURE 14. *Achtheres percarum:* after Claus (from Faxon). *Copepoda, Parasitica.* Larva at the time it leaves the egg, with only two anterior unbranched pairs of appendages of the typical nauplius present. Under the skin are the rudiments of six pairs of appendages: III, mandibles; IV, maxillæ; V, VI, maxillæ; VII, VIII, swimming feet.

FIGURE 15. *Balanus balanoides:* after Hoek (from Faxon). *Cirripedia.* Nauplius.

FIGURE 16. *Lernæodiscus porcellanæ:* after F. Müller (from Faxon). *Cirripedia, Rhizocephala.* Nauplius, ventral side; showing outline of dorsal shield.

FIGURE 17. *Sacculina purpurea:* after F. Müller (from Huxley and Balfour). *Cirripedia, Rhizocephala.*

FIGURE 18. *Cypris orum;* after Claus (from Faxon). *Ostracoda.* First larval (nauplius) stage, with bivalve shell and unbranched second and third pairs of appendages.

FIGURE 19. *Nebalia geoffroyi:* after Metschnikoff (from Faxon). *Leptostraca.* Side view of the so-called nauplius stage of the embryo within the egg. Rudiments are present of the two pairs of antennæ, I, II, the mandibles, III.

FIGURE 20. *Euphausia:* after Metschnikoff (from Faxon). *Schizopoda.* Nauplius, just hatched.

FIGURE 21. *Euphausia:* after Metschnikoff (from Faxon). *Schizopoda.* Nauplius at a later stage; ventral view; *mt*, metastoma; IV, V, maxillæ; VI, maxilliped. In the next, or Protozoëa, stage, the appendages, IV, V, VI, are true phyllopodiform feet.

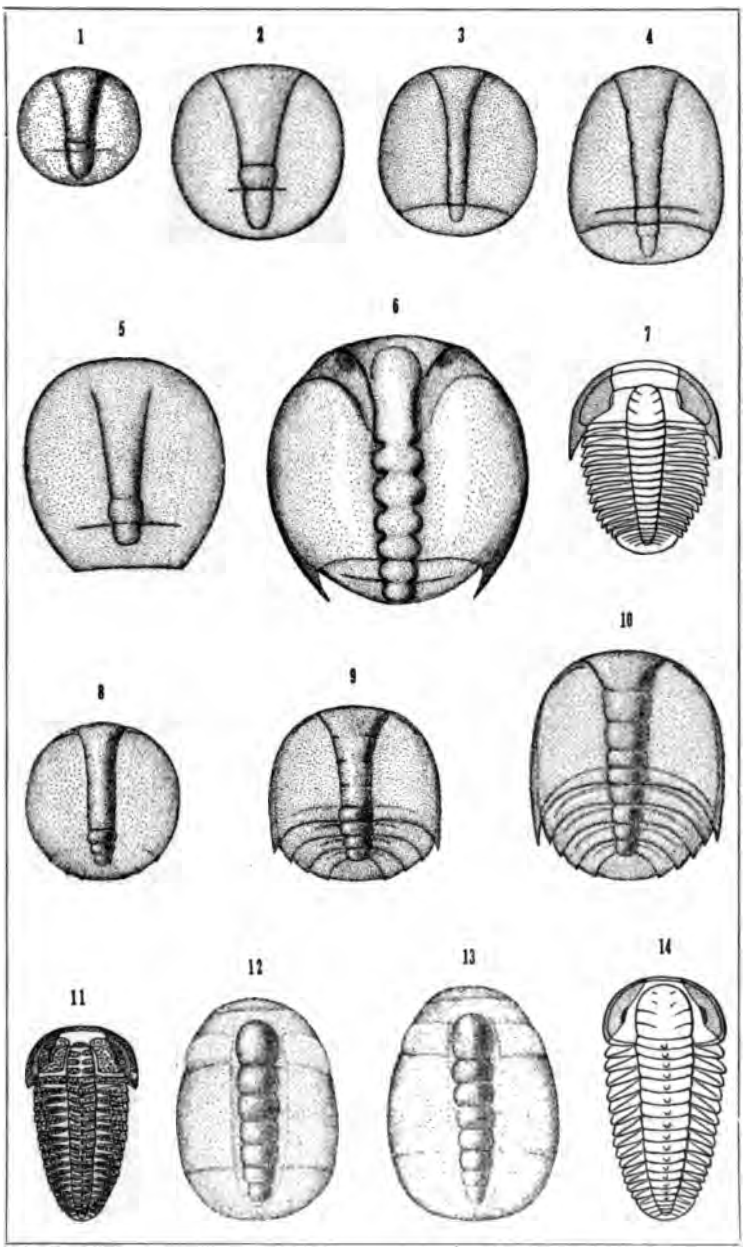
FIGURE 22. *Mysis ferruginea:* after Van Beneden (from Faxon). *Schizopoda.* Nauplius-like embryo; side view. The appendages are unsegmented, and the third pair quite rudimentary. A number of later metamorphoses are undergone in the nauplius skin, until the full number of appendages is developed.

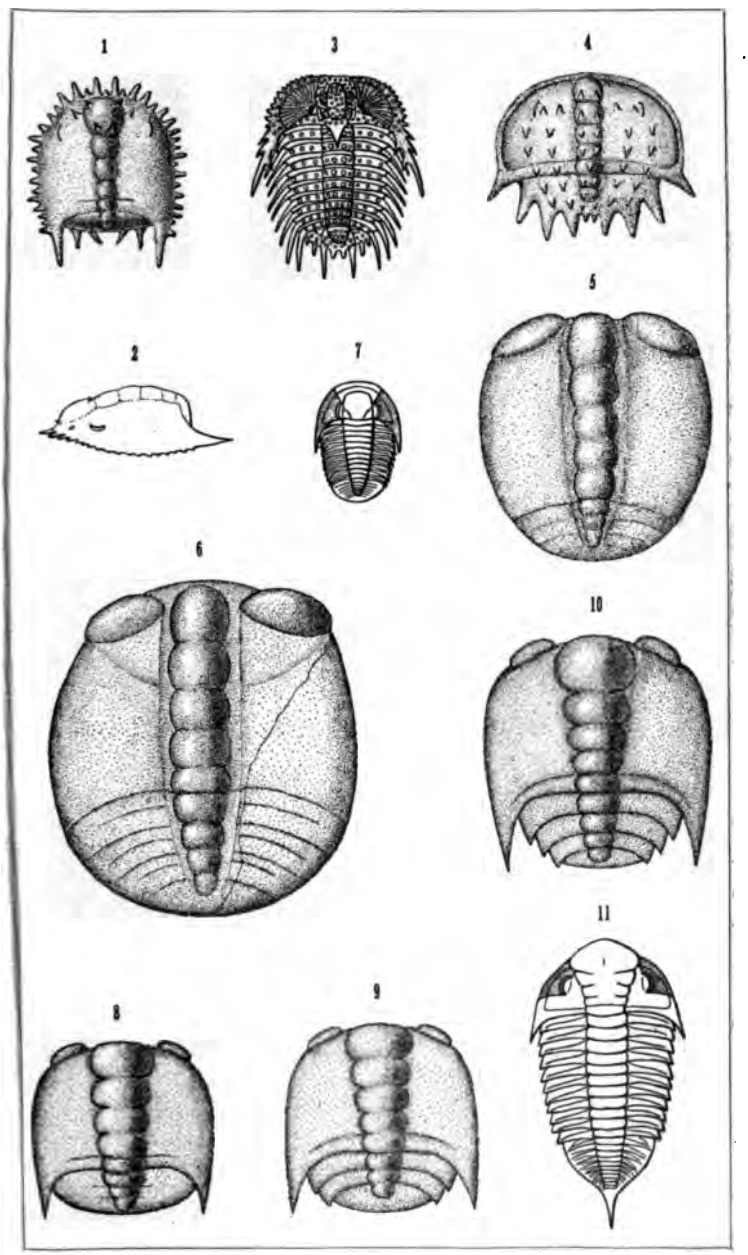
FIGURE 23. *Peneus:* after F. Müller (from Faxon). *Decapoda, Macroura.* Nauplius; from dorsal side.

FIGURE 24. *Lucifer:* after Brooks (from Faxon). *Decapoda, Macroura.* Ventral view of embryo artificially removed from the egg; IV, V, VI, buds representing the two pairs of maxillæ and first pair of maxillipeds of the adult.

FIGURE 25. *Palæmon:* after Bobretzky (from Faxon). *Decapoda, Macroura.* Nauplius stage of embryo within the egg.

FIGURE 26. *Astacus fluviatilis:* after Reichenbach (from Faxon). *Decapoda, Macroura.* Nauplius stage of embryo.


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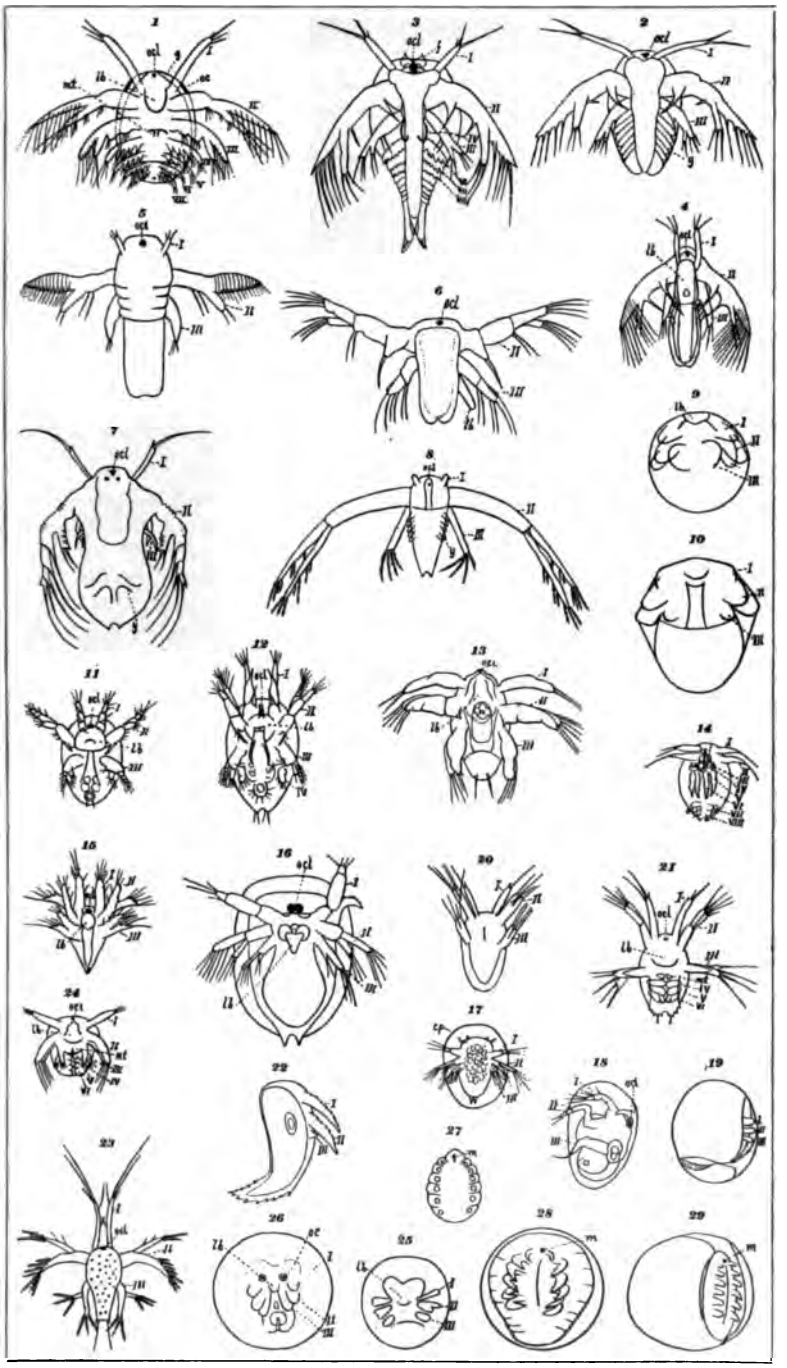


FIGURE 27. *Limulus polyphemus;* after Kingsley. *Xiphosura.* Ventral view of embryo; showing the budding of the legs.

FIGURE 28. *Limulus polyphemus;* after Packard (from Balfour). *Xiphosura.* Ventral view of embryo in the egg; showing the rudiments of six pairs of legs; *m*, mouth.

FIGURE 29. *Limulus polyphemus;* after Packard (from Balfour). *Xiphosura.* Oblique side view of embryo, with the mouth and rudimentary limbs on the ventral plate.

The figures of embryonic *Limulus* are introduced for comparison. They are so different from the nauplius that detailed notice seems unnecessary.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geological Survey of Canada, Annual Report (new series), vol. VI, for 1892-93. ALFRED R. C. SELWYN, Director. (Ottawa, 1895. Price 50 cents.) This volume includes the summary reports of the operations of the Survey during 1892 (95 pages) and 1893 (98 pages); a preliminary report on the geology of a portion of central Ontario, in the counties of Victoria, Peterborough, and Hastings, by FRANK D. ADAMS, 15 pages; a preliminary report on geological investigations in southwestern Nova Scotia, by L. W. BAILEY, 21 pages with map; chemical contributions to the geology of Canada, from the laboratory of the Survey, by G. CHRISTIAN HOFFMANN, 93 pages; and the annual report of mineral statistics and mines for 1892, by E. D. INGALL and H. P. H. BRUMELL, 212 pages, with 12 plates showing graphically the production of asbestus, coal, copper, iron, petroleum, phosphate (apatite), gold, silver, and salt (imported), during 1892 and preceding years. The parts of the volume as here noted are separately paged, with the addition of a letter to designate each part, so that they are indexed together.

Several other important manuscript reports, with numerous maps, resulting from the work of the Survey during the years here covered, are stated to be ready for the printer and engraver, but are unfortunately delayed in publication on account of inadequacy of the appropriation for this use. It is hoped that these will soon be issued in a succeeding volume.

The deep well at Deloraine in Manitoba, northwest of Turtle mountain, has been completed under the direction of the Geological Survey, boring to a total depth of 1,953 feet. The section consisted chiefly of the Ft. Pierre, Niobrara, and Ft. Benton shales, beneath which the top of the Dakota sandstone was reached at 1,822 feet from the surface, or about 178 feet below sea level. From the sandstone at 1,855 feet a feeble artesian flow of somewhat saline water was obtained, which, however, was shut off by the lowering of the casing as the boring was continued in the hope of securing a more copious supply. Because of the imperfect permeability of the sandstone, its lower supply of water rose

only to a level 60 feet below the surface. When pumped several days the water attains the warm temperature of 80 degrees F., showing that the downward increase of the earth's heat at this locality averages about one degree for each 43 feet, the mean annual surface temperature of the air and of the earth at a slight depth being about 35 degrees F. The mineral contents of this water considerably exceed those of the many mildly saline and alkaline artesian wells of the James River valley in North and South Dakota, which recieve their strong flows from the same sandstone at a less depth.

Shore-lines of the Champlain epoch have been traced by Mr. Robert Chalmers all around the coast of Prince Edward island, the postglacial and recent emergence having there attained a vertical extent of about 25 feet. It was somewhat more on the northwestern coast of Nova Scotia and much more in New Brunswick, amounting to 225 feet in the vicinity of St. John. These provinces, like Newfoundland, are wholly drift-covered, though with abundant rock outcrops: but the intermediate Magdalen islands in the Gulf of St. Lawrence are found to have never been enveloped by the ice-sheet. The rocks of these islands bear no striation nor boulder-clay, but are decaying and mantled with residuary soil. They have well defined Champlain shores, which are higher than on Prince Edward island.

During the year 1893 field work of exploration was carried forward by sixteen parties, of which four were in the province of Ontario, three each in British Columbia and Nova Scotia, two in the province of Quebec, and one each in the Northwest Territories, in eastern Manitoba and Keewatin, in the East Main district and Labrador, and in New Brunswick. Brief outlines of the results of all these explorations are noted.

W. U.

Summary Report on the Operations of the Geological Survey [of Canada] for the year 1894. By GEORGE M. DAWSON, Director. (Pages 124; Ottawa, 1895. Price 10 cents.) After only a very short interval from the publication of the foregoing volume, this first part of the next is issued. During 1894 it was found necessary to reduce the number of field parties to twelve, Ontario having three, British Columbia and Nova Scotia each two, and the Northwest Territories, Keewatin, Quebec, Labrador, and New Brunswick, each one, from all of which brief administrative reports are given.

Boring to test whether petroleum can be obtained in commercially important quality has been carried to the depth of 1,011 feet at Athabasca Landing. This work is to be continued to at least 1,500 feet, unless the stratum outcropping northeastward as "tar sands" shall be previously reached. It is hoped to find large supplies of petroleum in this Cretaceous formation, or in porous beds of the next underlying Devonian strata, whence the tar or bitumen is thought to have come by upwelling and evaporation.

Among the areas of new explorations, the most interesting are the country from lake Athabasca northeast to Chesterfield Inlet, and thence south along the west coast of Hudson bay, traversed by Mr. J. B. Tyr-

rell and his brother, as already noted in the AMERICAN GEOLOGIST (vol. XIII, p. 132, Feb., 1894, and vol. XIV, pp. 338-340, Nov., 1894), and the Labrador peninsula, which Mr. A. P. Low crossed from south to north and again from east to west and south.

Low's northward route was by lake Mistassini, the upper part of the East Main river, lakes Nichicun and Kaniapiskau, and down the Koksoak or Ungava river to Fort Chimo, near the debouchure of the river into Ungava bay. Finding great scarcity of provisions there, with famine and starvation of the Indians, Low and his party took passage on the Hudson Bay Company's steamer to Hamilton Inlet. Thence they went up the Hamilton river, by its expansion in lake Winokapau, to the Grand falls, where the river has 300 feet of sheer vertical plunge, with a very narrow and crooked cañon next below, about ten miles long and descending in that distance another 300 feet. Lake Winokapau was found to have a maximum depth of 416 feet, and was at one place 80 feet deep within 50 feet from the shore. From these soundings Mr. Low concludes that "the elevation of the land in preglacial times was much greater than at present, and that the valley of the Hamilton river has since been filled up with glacial drift; out of which the river is again cutting a channel; but owing to the less elevated state of the land it will probably not again reach the depth that it had previous to the glacial period." The Champlain subsidence and reëlevation at Hamilton Inlet, as shown by raised beaches, are thought not to have exceeded 200 feet.

In summing up his observations, Low writes: "The most important geological information obtained is the discovery of a great and hitherto unknown area of Cambrian rocks extending north-northwest from north latitude 53 degrees to beyond the west side of Ungava bay. These rocks are made up of a great thickness of conglomerates, sandstones, slates, shales, and limestones, together with intrusive igneous rocks. Their chief economic value is due to the immense amount of bedded iron ore found along with them. The ores are chiefly specular and red hæmatite, together with beds of siderite or carbonate of iron. Thick beds of fine ore associated with jasper were met with in many places, on both the Ungava and Hamilton rivers; and the amount seen runs up into millions of tons. Owing to their distance from the seaboard, these ores at present are of little value, but the time may come when they will add greatly to the wealth of the country." The similarity of these areas with the valuable mining districts of northern Michigan, Wisconsin, and Minnesota, seems especially noteworthy.

From observations of the glacial striæ and transportation of drift, it appears that the ice-sheet flowed outward "in all directions from a central area south of lake Kaniapiskau and between the headwaters of the Hamilton and East Main rivers." Upon the central tract, however, only a comparatively small amount of ice movement is indicated, for the ground, even to the very summit of the hills, is commonly covered by very abundant subangular blocks and boulders of the local rocks, while erratics are very rare.

After many years of service on the Canadian Geological Survey, Dr. Dawson is appointed to its directorship, which Dr. Selwyn lays down at the end of a successful administration through twenty-five years. We extend to the new director the wish that the work carried on and superintended by Logan and Selwyn may be as long and as prosperously continued under his direction. W. U.

Does the Delaware Water Gap consist of Two River Gorges? By EMMA WALTER. (Pages 8, with map, Proc. Philadelphia Acad. of Natural Sciences, March 13, 1895.) The topographic features of the Water Gap, the exceptional depth of the river, 35 to 50 feet, in the gorge, while it is shallow with rapids above and below, and the hights of the valley terraces of gravel and sand, are regarded as evidences that the greater part of this gap, passing through the Kittatinny or Blue Mountain range, was cut in preglacial times by a river flowing there northwestward, opposite to the present course of the river, which since the Ice age is thought to have cut the lowest 150 feet of the southeastern part of the gorge. The depth of the river, however, seems no more than may be attributed to the force of its floods in this constricted and curved part of its channel. W. U.

En resa till norra Ishafvet sommaren 1892. By AXEL HAMBERG. (Pages 25-61, with map, and 14 figures in the text, views engraved from photographs; Ymer, 1894.) In the northeastwardly facing frontal cliffs of Loven's glacier, near the shore of King's bay, Spitzbergen, much englacial drift was observed. The ice is distinctly stratified, and the inclosed drift occurs chiefly in definite layers, separated by others of nearly clear ice. Where a boulder is imbedded, the ice laminæ curve upward over it and downward under it. Sigmoid folds and overthrust faults have been produced by the differential motion of the ice strata. Loven's glacier thus presents very conspicuously the same conditions which Chamberlin has described from his studies, two years later, in northern Greenland. W. U.

The Protolenus Fauna. By G. F. MATTHEW. (Trans. N. Y. Acad. Sci., vol. 14, pp. 101-153, pls. I-IX, 1895.) *Protolenus*, Matthew, is a trilobite genus closely allied to *Olenellus*. The Protolenus-fauna is the oldest known Cambrian fauna in the New Brunswick section. It lies immediately beneath the Paradoxides beds, and is otherwise denominated by the author as the fauna of Band *b* of division 1, or the Acadian division of the St. John group. The "Olenellus-zone" which in New Brunswick, and generally throughout the Atlantic region of North America, in Scandinavia, etc., lies beneath the Paradoxides horizon, has not been found in New Brunswick. It would seem that the fauna with Protolenus occupies the stratigraphical position of the Olenellus-zone.

The author had already described certain species of this fauna, but the number has been much enlarged and their distribution established with greater precision, by the diligent collecting of Messrs. W. D. Mat-

thew and Gilbert von Ingen. The assemblage of species, to the description of which most of these pages are given, is an interesting and in many respects highly remarkable one. The author's well known keenness of observation is displayed to admirable advantage in these descriptions and the accompanying illustrations. Some of the more striking elements in the fauna are here briefly noticed:

The determination of Foraminifera of the genera *Orbulina* and *Globigerina* (8 species) is one of much interest, originally due to Mr. W. D. Matthew. To the Spongida are referred some doubtful bodies designated as *Monadites*, *Protospongia* and *Astrocladia*. The list of Brachiopoda presents an assemblage of noteworthy forms; typical Lingulellas; *Botsfordia*, an oboloid genus founded upon the species *Obolus ? pulcher* Matth., to the illustration of which an entire plate (III) is given; a species of *Obolus* (*O. pristinus*) which, if correctly referred, is the sole American representative of the genus: the interesting genus *Trematobolus*, Matthew, (type, *T. insignis* Math.) an obloid shell with certain siphonotretid characters and articulating apparatus is redescribed at length; species of *Obolella*, *Linnarsonia*, *Acrotreta* and *Acrothele*. Among the Mollusca are representatives of some interesting genera, such as *Orthotheca*, Novák, *Diplotheca*, Matth., with its septate hyolithoid shell, and *Volborthella*, another septate supposed pteropod. *Pelagiella* is a new generic name introduced for a small spiral Platyceras-like shell, believed to represent a heteropod; *P. atlantoides* is the type.

The ostracodes are represented by eighteen species, among them forms belonging to the author's genera *Hipponicharion* and *Beyrichona*, with others referred to *Primitia*, *Aparchites*, *Schmidtella*, and *Leperditia*. To the Phyllopoda is doubtfully referred the genus *Lepiditta*, Matth. (*L. sigillata*, type.)

The Trilobites present a number of new things: a new genus, *Protagraulos* (type, *P. priscus*), founded on a small cranidium of very primitive type, with unsegmented glabella and long eye-lobes; another, *Micmacca* (type, *M. matthevi*), based on large cephala with broad, subquadrate, obscurely lobed glabella extending to the frontal margin, and elongate eye-lobes. Four species of this genus are described. *Bergeronia* is a new term applied with subgeneric value to a form previously described as *Protolenus elegans*, W. D. Matth. The difference from *Protolenus* is stated to be wholly in the form of the thoracic segments, those of that genus being flat, with a diagonal furrow, while in *Bergeronia* they are strongly grooved and geniculate. The list contains also species of *Ellipsocephalus* and *Avalonia*, and of the entire number of trilobite species, seven are new. The entire fauna lists seventy-four species and varieties.

In his conclusions the author shows that the Protolenus-fauna, on account of the absence of characteristic types, can not be regarded as the fauna of Olenellus, whatever its stratigraphical relations to that fauna may be. Further, that the fauna with *Protolenus* is more primitive than that with *Olenellus*: as evinced, for example, in the long continuous eye-lobes of all the trilobites: and also more pelagic, as shown by the presence of Foraminifera and Heteropoda. J. M. C.

CORRESPONDENCE.

RECENT GEOLOGICAL WORK IN SOUTH DAKOTA. By the direction of the State Board of Regents of Education the School of Mines of South Dakota sent two parties into the field in May and June of this year.

The general oversight of the work was placed in the hands of the state geologist. One party, consisting of Prof. F. C. Smith of the School of Mines and several of his students, spent the time in carefully examining the section of the Black hills along Rapid creek, with the special purpose of unravelling the complicated structure of the Algonkian slates and quartzite. The other party, consisting of myself and one assistant, made an extended reconnoissance of the northwestern portion of the state. The following points of general interest to geologists were ascertained and it is thought best to place them on record before the preparation of a more careful report.

1. Numerous small bivalve shells have been found in the Purple limestone which lies in the Red beds and which has been reported by all previous observers as entirely without fossils.

2. Numerous folds of great extent and of very complex character are found to occur in the slates along Rapid creek in the eastern portion of the Black hills. Also an important advance in the tracing of the extent and subdivisions of the Algonkian.

3. Miocene beds, both White River and Loup Fork, with characteristic fossils, have been found overlying wide areas of the Laramie north of the Black hills, covering quite deeply most of Harding county, with thin outliers over the north half of Butte county and south half of Ewing. In the Short Pine hills and Slim buttes these deposits exhibit a depth of 200 to 400 feet with characteristic fossil features closely resembling those of the White River region.

4. An area of disturbance was found in the north half of Slim buttes in northeast Harding county covering perhaps 20 to 25 square miles. This consists of sharp folds, including the Laramie and White River beds, with throws of perhaps 100 feet and dips of 25 degrees.

5. Upon these beds lie horizontal strata of white sandstone over 100 feet in thickness, doubtless of the Loup Fork age. Photographs of instructive exposures were secured.

6. The lignite beds of the Laramie of North Dakota and Wyoming are found to extend so as to underlie most of Ewing, Harding and Martin counties. These features are quite constant in thickness over wide areas, especially toward the north. Two of them, four to five feet in thickness, underlie the Cave hills, and the lower one extends scores of miles under the surrounding country. In some places, as in the north half of Slim buttes, three beds were found, five, six and ten feet in thickness, in a vertical distance of 50 or 60 feet. With these great quantities of fossiliferous clays, affording beautiful specimens of fossil leaves, were found.

J. E. TODD.

Vermillion, S. D., Aug. 5, 1895.

PERSONAL AND SCIENTIFIC NEWS.

MR. W. D. MATTHEW, of Columbia College, has been appointed assistant in vertebrate paleontology in the American Museum of Natural History.

PROF. JOHN MILNE, the well known seismologist, is about to return to England. For several years he has been connected with the Royal University at Tokio, Japan.

PROF. J. F. KEMP has conducted the geological work of this year's Summer School of Columbia College at Central City, Colorado. In August and September he will be engaged in field studies in the Adirondacks. During Prof. A. J. Moses' absence the coming year Prof. Kemp will act as managing editor of the School of Mines Quarterly.

PROF. VALENTINE BALL, director of the Museum of Science and Art of Dublin, died on June 17th, at the age of 52 years. He was elected a fellow of the Geological Society of London in 1874, fellow of the Royal Society in 1882, president of the Royal Geological Society of Ireland in 1882, and was professor of geology and mineralogy in the University of Dublin from 1881 to 1883.

MR. F. W. SARDESON, formerly instructor in paleontology in the University of Minnesota, has this summer taken the degree of Doctor of Philosophy at the University of Freiburg. His first work in Freiburg was the reëxamination of the Dogger of the Upper Rhine valley, which has proved a perplexing puzzle for some years. By the discovery of a few new localities for fossils he was able to establish the following succession, in ascending order: 1. Murchisonæ-Schichten; 2. Sowerbyi-Schichten; 3. Blaue Kalke; 4. Giganteus-Thone; 5. Humphriesi-Schichten; 6. Coronatus-Schichten; 7. Subfurcatus-Schichten; 8. Hauptrogenstein. (Mitt. d. Grossh. Badischen Geol. Landes., Bd. III, Heft. 2, S. 109-117, Taf. 2, 1895.)

THE UNITED STATES GEOLOGICAL SURVEY. *Science* for July 19th, gives an extended abstract of the report of director Walcott for the month of May, 1895. He remarks on the early commencement of field work this season as compared with former years, with the prospect of a longer season and more abundant results. The topographic parties nearly all took the field during May, as did also a number of geologic parties. Such topographers and geologists as were detained in Washington beyond the close of the month have since taken the field from time to time, as the exigencies of the work already in hand permitted. This early commencement of the field work of the Survey is attributable in the main to the action

of Congress in providing in the last Sundry Civil bill that the appropriations for the Survey for the fiscal year 1895-1896 should become available before the first of July. The different directions in which work is progressing and the work of the various geologists is given in some detail.

DR. M. E. WADSWORTH, director of the Michigan Mining School, delivered an address before the graduating class of the L'Anse (Mich.) high school this summer. He makes a plea for mining engineering as the best field for many a young man to enter. We quote the most interesting and important part of the address:

The engineering lines offer opportunities for as high an education and the exercise of as great ability as any other profession, while the rewards are often great. * * * * * In my judgment mining engineering now offers one of the best fields for any industrially inclined young man. The reason for this is the especially broad and varied training a man obtains in his preparation for this profession. The object of the training is to teach a man to aid in the development of the mineral wealth of the country. In doing this the student is instructed how to explore the field and forest, to know the valuable and useful minerals and rocks and to distinguish them from those that are not useful, to understand the geological principles that govern the formation and association of all useful mineral deposits and to be able to approximately estimate their value: to survey and lay out the property for opening, and to map it accurately: to design or select the hoisting, transportation, power and light plants: to design and erect the mills, furnaces, docks, dams, etc.: to survey, lay out and plot the town, roads, railroads, tramways, etc.: to understand the methods of mining or quarrying the deposit, of timbering and ventilating the mine; assaying the ores: to understand the strength and properties of construction materials, the improved methods of generating and using steam, the care of boilers, engines and pumps, how to test them and determine their efficiency; make repairs, handle machine and other tools: to know the principles of electricity, its generation, storage, transmission and use, and to design and lay out plans suitable for its use in lighting, haulage, etc.: to understand hydraulic mining, the use and transmission of water power: the flow of water through pipes, ditches, etc.: and the various problems of water supply, drainage, sewage, etc.: to intelligently select the methods of handling any ore, to dress and concentrate it, to understand its constitution, and to choose the metallurgical processes by which it should be treated: to be conversant with the methods of keeping the accounts and books relating to mines, making the purchases, selling the products, etc. Such a training as this makes a man not only useful about any part of the work in obtaining mineral products, but it makes him valuable in almost every walk in life.

It is easy to see that such an education will make any man of reasonable intelligence a fair mathematician, physicist, chemist, assayer, metallurgist, mineralogist, geologist, draughtsman, designer, surveyor, a civil, mechanical, electrical and mining engineer, woodsman, mechanic, millman, etc.

THE OCTOBER NUMBER OF THE AMERICAN GEOLOGIST will contain an account of the meetings of the Geological Society of America and the American Association for the Advancement of Science at Springfield, Mass., August 27th to September 7th.

ER. 1895. VOL. XVI, NO. 4.

THE AMERICAN GEOLOGIST

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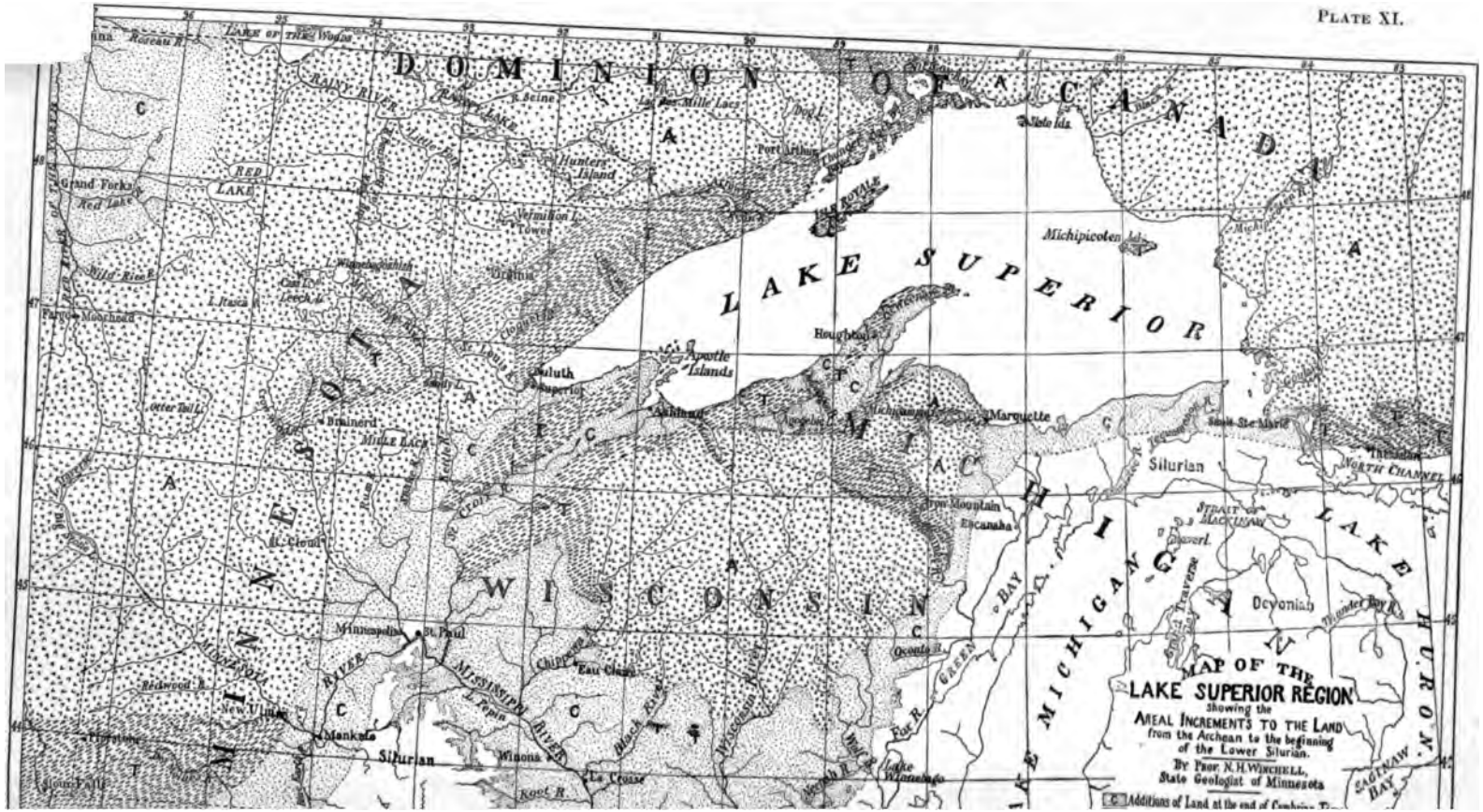
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Minneapolis
St. Paul
Mankato
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La Crosse
Marquette
Houghton
Silurian
Devonian
MAP OF THE
LAKE SUPERIOR REGION
showing the
AREAL INCREMENTS TO THE LAND
from the Archean to the beginning
of the Lower Silurian.
BY PROF. N. H. WINCHELL,
State Geologist of Minnesota

THE

AMERICAN GEOLOGIST.

VOL. XVI. OCTOBER, 1895. No. 4.

[CRUCIAL POINTS IN THE GEOLOGY OF THE LAKE SUPERIOR REGION. No. 8.]

THE SYNCHRONISM OF THE LAKE SUPERIOR REGION WITH OTHER PORTIONS OF THE NORTH AMERICAN CONTINENT.

By N. H. WINCHELL, Minneapolis, Minn.

(Plate XI.)

After this glimpse of the succession of events in the Lake Superior region it will be well to institute another comparison with eastern localities, showing a general synchronism of the geology of lake Superior with the Adirondack and Taconic areas. Reference has already been made to the occurrence of eruptive rocks in the Canadian territory which is immediately adjacent to these rocks in Minnesota, considered Lower Cambrian by Dr. Selwyn, and to others further north which Dr. G. M. Dawson has mapped as Lower Cambrian and places at about the same age as the copper-bearing rocks of lake Superior. The succession of geological changes, as now made out, in the Lake Superior region, appears to be expressed as follows. This leaves out of the account the latest of the volcanic convulsions, viz., that which caused the intrusion of the traps that cover the light colored and marly sandstones at Black bay and which produced, according to Dr. A. C. Lawson, the *Logan sills* of the Animikie* at a considerably later date than the Keweenawan epoch, and which will be considered later. It embraces only the essential steps that are covered by the

*Bulletin VIII, Minnesota Geological Survey, p. 47.

classification embodied in the Bulletins of the United States Geological Survey, which are here examined (Nos. 81 and 86). They are given in descending order.

Succession of Geological Events.

(I.) A great sandstone, non-conformable over (*a*) the Archean; (*b*) the lower iron-bearing series (Keewatin); (*c*) the upper iron-bearing series (Animikie) and its eruptives; (*d*) parts of the Keweenawan. It is conformably under sandstones carrying an Upper Cambrian fauna. *The Dicellocephalus horizon.*

(II.) Disruption, folding and metamorphosing of the rocks of No. III, accompanied by the issuing of basic molten rock, and perhaps by the fusion of some of the clastics. Eruptives cotemporary with and followed by clastic sediments of great thickness. *Keweenawan eruptive age.*

(III.) Great quartzyte and conglomerate, underlying the last, non-conformable over all the older formations, after a great erosion interval. *The Keweenawan basal beds, Paradoxides horizon.*

(IV.) Great upheaval and metamorphosing of the rocks of No. V, accompanied by the formation of enormous dikes and masses of gabbro with titanic iron ore, and of anorthosyte rock, the fusing of the clastics of No. V and the production of quartz-porphyries and felsytes on a large scale. *The Animikie revolution.*

(V.) Black slates and reddish to grayish quartzytes (Wauswaugoning), iron ore (Mesabi), quartzyte. Slates sometimes converted to fine-grained crystalline schists and magnetited, and to gneisses. Quartzytes and slates changed sometimes to quartz-porphyry and keratophyre. A limestone, often marmorized, of greater or less thickness belongs near the bottom. *The Animikie. Supposed Olenellus horizon.* Non-conformable on the different parts of the Archean.

(VI.) An unconformable underlying complex of crystalline rocks.

It is scarcely necessary to dwell on this statement of the sequence of geological events in the Lake Superior region. This history has been established by the combined observations of numerous geologists during the last thirty years. Probably no geologist who is acquainted with the region would call in question any of the events above expressed, or the relations indicated. There are of course many minor matters, more in the detail of subdivision and derivation for the different parts, on which geologists would not be found in accord, but the grand steps of the history as tabulated, whatever the age at which they occurred, are accepted by nearly all.

Attention may now be called to the parallelism of this structural series with that already expressed for the Adirondack and the Taconic areas.

*Parallelism between the Eastern New York and the Lake Superior Region.**

Lake Superior.	*Eastern New York.*
(*a*). Upper Cambrian (Dicellocephalus) fauna, embraced in magnesian limestones and siliceous sandstones.	(*a*). Upper Cambrian fauna embraced in magnesian limestones and siliceous sandstone.
(*b*). The upper parts of (*a*) non-conformable on some of the earlier rocks, indicating a progressive submergence. Contact on the trap at St. Croix falls. *St. Croix.*	(*b*). The rocks of the Upper Cambrian fauna non-conformable on the older rocks—both crystalline and uncrystalline. Contact on the "hypersthene rock." *Calciferous.*
(*c*). The base of (*a*) is a sandstone, and a conglomerate and is non-conformable on the rocks of (*e*) and of (*g*), and the sandstones also on some parts of (*d*). *Lake Superior sandstone.*	(*c*). The basal parts of (*a*) are a sandstone and conglomerate, widely transgressing the older rocks. This sandstone is also non-conformable with parts of (*f*). Upper part of the *Potsdam sandstone.*
(*d*). Basic irruptives and surface flows, accompanied by acid igneous rocks; these interstratified with clastic rocks. *Keweenawan.*	(*d*). Not certainly identified, but probably in the "eastern townships" of Canada. Not yet separated from (*f*).
(*e*). Underlying the eruptives of (*d*) is a great quartzyte and conglomerate, very compact and firm. The *Sioux quartzyte* containing *Paradoxides* and *Lingula.* This is non-conformable on all the older rocks. In Wisconsin *Palæacmæa*† *irvingi* is evidently from this horizon.	(*e*). A hardened sandstone or quartzyte lying, with a basal conglomerate, non-conformable on crystalline schists. The true *Potsdam sandstone* at Potsdam, and eastward to the Au Sable gorge. *Hyolithes, Palæacmæa, Conocephalites, Lingula.*
(*f*). Massive basic irruptives; acid eruptives; titanic iron ore; anorthosytes, associated with the rocks of (*g*) which they change to crystalline conditions. *The Animikie revolution.*	(*f*). The "hypersthene rock," o gabbro, of th' Adirondacks with its titanic iron ore. The *Upper Laurentian of the Adirondacks*, in part.
(*g*). Slates, limestone, quartz-schist, hematite iron ore, upheaved and crystallized; mica schists and gneisses. The Mesabi and the Penokee rocks. *The Animikie.*	(*g*). Mica schists, marbles, quartzyte, magnetic iron ores, gneiss. Marbles and quartzytes have *Olenellus* in Vermont. Part of the *Upper Laurentian* of the Adirondacks, and the *Taconic* of Vermont.

*The Eastern New York region in this connection is supposed to include adjacent areas in Canada and New England.

†In Wisconsin, seven miles west from Merillan, in Jackson county, are mounds of quartzyte (white and pink) similar to the quartzyte at Baraboo, except they are not so dark, from which this fossil evidently was obtained. Geol. Wis., vol. IV, p. 173.

(*h*). Great non-conformity on the Archean. The rocks of (*g*) are sometimes folded with the Archean so as to cause them to be confounded.	(*h*). Unconformity on the Green Mountain gneiss and on an older series in the Adirondacks, as lately announced afresh by Kemp.
(*i*). Oldest known series of crystalline rocks. *Archean.*	(*i*). An older series of crystallines.

Lithological Constants.

Much has been said in late years against the evidence of lithologic similarity as a guide to the parallelism of rock outcrops in different localities; but when it is remembered that in the earlier epochs of geological history great uniformity of oceanic and physical conditions spread over vast expanses of the earth's surface, and that differentiation of no kind had advanced very far, it is perhaps more reasonable, in the case of the epochs which we are considering, to expect a uniformity of rocky structure over large areas than a cotemporary diversity. Physical effects, as they are manifested in the ocean's drama of sedimentation, were not modified by great variations of depth, nor by continental shores. It was only when the heaving of the thin crust, perhaps under changing astronomic influences, finally broke it and allowed the molten interior to escape to the surface, that the repose of eons was disturbed and the sedimentary succession was varied. In the light of the facts which are brought together above, making a lithological and structural comparison between the eastern portions of New York and the Lake Superior basin, in Taconic time, it is at least not unreasonable to question the wisdom of the common practice of casting out as unreliable all evidence derivable at this horizon, from a comparison of lithological characters. In order to make this plainer it will be well to emphasize the constant lithological features that are known to have prevailed, simultaneously, in the two regions.

To do this but little more is necessary, at the first glance, than to refer to the sequence as already stated in the foregoing tables. There are, however, some remarkable rock species, unlike any found in any other part of North America, either in earlier or later geological history which occur coincidently at these distant points. First of all the great anorthosyte series stands prominent. This remarkable group under the names Norian, Upper Laurentian and Hypersthene

rock, or simply gabbro, embracing the crystalline apatites and the titanic iron ores of the country, and, as dependencies, certain marbles and quartzose gneisses with their graphite and non-titanic magnetites and a large variety of novel mineral species, protrudes itself upon our notice. That it should appear in North America at so widely separated points, at essentially, if not precisely, the same time in the early history of the earth, is a remarkable event which calls for some explanation other than the ordinary reference to oceanic conditions. This great plutonic agitation appears to have been felt along a belt extending from southern New York northward through the Adirondacks, through Canada, appearing on the north shore of lake Huron, where coarse eruptives are mingled with the broken and subcrystalline strata of the "original Huronian," to lake Superior and the region of Duluth, occurring on both sides of the great basin. More recently a gabbro of similar character has been discovered about 120 miles still further west in Minnesota. How far southward along the Appalachian fold this effect can be distinguished from that of other epochs of irruption and crystallization is unknown, but similar gabbro rock has recently been announced in the vicinity of Philadelphia* and Baltimore.† The actual eruption of the characteristic labradorite-anorthosite rock may not have prevailed in all those regions throughout which, still, the cotemporary folding and metamorphic changes were imprinted on the earlier rocks. In the latter effects this epoch may perhaps yet be identified over wide areas on the Appalachian mountains and its rocks may be found to extend much further northeastward toward the mouth of the St. Lawrence, and to be of the age of the rock in Labrador from which its chief feldspar is named.

Another lithological constant involved in the rocks of the Taconic from eastern New York and Vermont to northeastern Minnesota is the iron ore horizon which appears overlying the basal quartzyte of the Animikie. That this must have depended on oceanic causes inherent in the Taconic for its stratigraphic position as well as for its geographic extent, is

*J. F. Kemp. On an occurrence of gabbro (norite) near Van Artsdalen's quarry, Bucks county, Pennsylvania. Trans. N. Y. Acad. Sci., vol. xii, March, 1893.

†G. H. Williams. Bulletin 28, U. S. Geol. Sur., 1886.

evident. That its existence, whether the ore be hematite (or limonite) or magnetite, must be based in some cause equally applicable of operating over areas so widely separated at the same time, is equally apparent. That it antedated, in part at least, the main gabbro disturbance, which closed the Animikie portion of the Taconic, is plain, since the gabbro has rendered it magnetite where it has been in contact with the gabbro. It is with some satisfaction that it can now be stated that work recently done for the Minnesota survey by Mr. J. E. Spurr, after prolonged investigation into the environments of the iron ores of the Mesabi range, has resulted in a substantial demonstration of the oceanic nature of the rock from which the ore is produced by metasomatosis and of the probable existence of organisms in the cotemporary Taconic ocean as the primal source of the ore.* In short, Mr. Spurr's result on this point indicates that the iron ores of this geological horizon were at first in the form of greensand, and that foraminiferal remains contributed to the unstable chemical condition in which the primary glauconite rock was formed. This important discovery accords with other facts known before which pointed toward a very early oceanic origin for these ores. It also explains their existence at the same stratigraphic plane and over a wide extent.

Chondrodite, a characteristic mineral of the limestones of the Taconic in New York and New Jersey, at first supposed to be proof of their Archean age, also accompanies the limestones of this horizon in Canada,† but has not yet been reported further west.

Without further specification of the lithological constants of the Taconic it may finally be remarked that the usual rock kinds, such as sandstone, limestone and graphitic slates,which succeed each other in these strata in the east and in Minnesota, when the same are non-crystalline, are quite similar and occur in the same successional order, and when crystalline are converted into quartzytes, schists and marbles having noticeable peculiarities; and that, finally, they are accompanied in the two regions by almost an identical succession of physical disturbances, manifesting cotemporary non-conformities in the stratigraphy.

*Bulletin X, Minnesota Geological Survey, 1894.

†Geology of Canada, 1863, p. 586.

Map of the Lake Superior Region.

The accompanying map of the Lake Superior region (plate XI) is designed to show the approximate areas of land and water at three different times in the progress of events as above projected, throughout the Lake Superior basin.

The areas designated by A represent the land at the close of Archean time, or just prior to the opening of Taconic time. As the Taconic seems to have been inaugurated by a widespread submergence, as indicated by the extensive conglomerate which forms its base, even at points somewhat remote from its present surface boundaries (which themselves may be supposed, however, to have been driven back by degradation some distance from their original positions) it is probable that the land areas at the close of the Archean were considerably larger than here shown. It is, however, obviously impossible to even approximate a correct representation of the actual Archean land in those tracts which are still buried beneath sediments of Cambrian and later date. This map therefore shows simply a representation of Archean areas that are now known to be exposed at the surface. The term Archean here covers all the basal crystalline complex which is found in a crumpled condition unconformable below the Taconic and which has been divided by Lawson into Laurentian, Couchiching and Keewatin. It includes the lower iron-bearing rocks of the Lake Superior region, but not the upper.

Areas designated by T show the land increments due to rocks of Taconic age, including in this the areal extent of the eruptives of the Norian and of the Keweenawan, the latter of which brought Taconic time to a close. The difficulty of mapping the later eruptives as an integral part of post-Taconic time is the principal reason for putting them with the Taconic. Again they are so intimately associated with the earlier eruptives and with the metamorphic conditions of the clastic strata of the Taconic of which they embrace large masses, and between the planes of which they have penetrated as conformable layers, that to separate them in such a map would be impossible. Chronologically they are post-Taconic, and on their upper surface lies the base of the rocks of the Dicellocephalus zone. They simply form a punctuation datum in geological history, belonging as much to what precedes as to that which

follows, but at the same time not a chronologic fraction of either as a faunal zone. Within the Taconic area are included the upper iron-bearing rocks of Minnesota, which in Michigan and in some parts of Wisconsin are so closely folded with the rocks of the lower iron-bearing series that they have never before been mapped separately in those states. The attempt here made to separately indicate them must be considered, therefore, as only a very general provisional mapping.*

Areas designated C show the additions which were made to the land area by the elevation of those rocks which immediately followed the eruptive Keweenawan and yet preceded the base of the Lower Silurian—i. e. up to the bottom of the Trenton limestone. These are distinctively the "Upper Cambrian" of the region and are the only rocks which in the final Minnesota reports have been mapped as Cambrian, the Lower Cambrian having been called Taconic.

The foregoing presentation of comparative facts of structure, lithology and paleontology, as expressed on the accompanying map, render the following conclusions both reasonable and probable:

1. The rocks of the Cortlandt series (the clastics), of the original Taconic area and of the upper series of the Adirondacks, are of the same age, i. e., Taconic or Lower Cambrian.

2. The basic rocks of the Norian or Upper Laurentian system of Canada are of the same age as the gabbros of the Adirondacks.

3. The Taconic in America embraces all the strata containing any known fossils older than the Dicellocephalus zone, or Upper Cambrian. It is separated from the Archean by a profound non-conformity.

4. The Animikie strata in Minnesota and in general the upper iron-bearing series of the Lake Superior region are of the age of the Taconic.

5. There are great objections to the supposition that the Taconic age is represented in the Lake Superior region by a supposed erosion-interval between the red sandstones of the Upper Cambrian (St. Croix or Dicellocephalus zone).

*Van Hise's map of the Penokee series accompanying the Monograph on the Penokee Iron-bearing rocks of Michigan and Wisconsin (Mon. XIX, U. S. Geol. Survey) has been published since this map was constructed. It would not, however, essentially modify it.

6. These are so great that, in consequence of other considerations that lead to the belief that the two sandstones are essentially the same formation, it is better to consider them as one, although manifesting many evidences of disturbance by the eruptive action which prevailed during their deposition and later.

7. The Taconic age, therefore, is represented in the Lake Superior basin, as in New England and Newfoundland, by a great series of quartzytes and slates and a few limestones.

8. Those rocks which have been described and mapped as Keweenawan embrace three eruptive systems,* separable by two erosion intervals marked by basal conglomerates and by faunal differences, viz., the eruptives of the Animikie revolution, those of the Keweenawan proper, and the eruptives of the region of Thunder bay and Black bay.

9. We may add as a corollary of the foregoing that the ocean which covered the spot where North America was to exist was subject to forces which acted simultaneously on a very wide extent, producing oceanic deposits of like nature and of like succession, in widely separated regions; and, again, that some other widely operating forces caused the simultaneous elevation, depression and, finally, the breaking of the crust and the escape of vast quantities of basic rock at points far distant from each other.

BRACHIOCRINUS AND HERPETOCRINUS.

By F. A. Bather, London, England.

The comparison to which I desire to direct the attention of American palæontologists seems to me, now that it is once made, so obvious that I am quite ashamed of not having noticed it before.

In the "Paleontology of New York"† Prof. James Hall founded a genus *Brachiocrinus*, taking as its type a new species, *B. nodosarius*, represented on plate V, figures 5-7, and plate VI, figures 1-3. The type-specimens were supposed by Prof. Hall to be the arms of a crinoid, to which structures they do indeed bear a strong external resemblance. Further, in the

*The next paper of this series will describe the youngest of these systems.

†Vol. III, p. 118.

"Revision of the Palæozoic Crinoidea,"* Messrs. Wachsmuth and Springer alluded to the fossils as "arm-fragments," and in their privately issued "Index" the name was printed in italics, as being invalid.

Now, I have little doubt that the fossils in question are not arm-fragments but stem-fragments, and that they belong to the same genus as the fossils also described by Prof. Hall as arms, under the name *Myelodactylus*, and correctly described by J. W. Salter as stems, under the name *Herpetocrinus*. A detailed account of the literary history of those names and a minute description of the structure of those fossils was given in my "Crinoidea of Gotland. Part I. Crinoidea Inadunata"† on pages 36-52. It is therefore needless to repeat here the reasons for preferring the name *Herpetocrinus* or for regarding the ordinary specimens as portions of stems. I will merely point out the reasons for a reconsideration of the status of *Brachiocrinus*.

That the remains are not arms follows from the fact that there is, as shown on plate VI, figures 1 and 3*a*, of Prof. Hall's work, no ventral ambulacral or food groove on the main stem, while the supposed pinnules (tentacula of Hall) are stated to be "without any appearance of a groove or canal on the inner side." Further, our present knowledge does not permit us to imagine a solitary arm, "without any appearance of an articulating surface or point of attachment to any other body," but terminating "below in a rounded condyle;" "as if the arm, as it now occurs, had had an independent existence."

On the other hand, the remains agree in essential structure with the stems of other crinoids. The tentacula, or cirri as they should now be called, are round in section, "with a linear foramen" or axial canal, which in plate V, figure 7, is seen to pass into the main stem, where it doubtless joins an axial canal in the stem. This latter, it is true, is neither mentioned in the text nor shown in the section (plate VI, figure 3*a*); perhaps, as in many undoubted specimens of *Herpetocrinus*, the axial canal has been obliterated by the processes of petrifaction. The rounded condyle at the distal end of the stem is also no without parallel in other crinoids, e. g., *Calceocrinus* and *Mil*

*Part II, p. 229, Proc. Acad. Nat. Sci., Philadelphia, 1881, p. 403.

†K. Vet. Akad. Handl., Bd. xxv, No. 2, Stockholm, 1893.

lericrinus; and it is no unusual thing to hear of stalked crinoids attaining to a semi-locomotor existence.

Next, to show that the remains called *Brachiocrinus nodosarius* are referable to *Herpetocrinus*. The coiling of the stem, as in plate V, figure 7, is notoriously characteristic of that genus; so also are the paired cirri, which give the stem the semblance of a pinnulate arm. The slight groove on the inner curvature, represented in plate VI, figure 1, is also found in all species of *Herpetocrinus*, while the section, plate VI, figure 3*a*, may be compared with the numerous sections figured in "The Crinoidea of Gotland," text-figure 12 and plates I and II.

It is true that in the excellent drawings by F. B. Meek, which adorn Prof. Hall's volume, one cannot see any of the minuter details and anatomical structures which a prolonged study of a very large number of Swedish and English specimens has enabled me to demonstrate in my memoir. There may, therefore, still be room for doubt as to whether the species is actually a *Herpetocrinus*. Mr. Charles Wachsmuth informed me some time ago that *Herpetocrinus*-like forms occurred in an order of crinoids other than the Inadunata; so that *Brachiocrinus* might conceivably be generically distinct from *Herpetocrinus*. I cannot, however, think that this is really the case. So far as I understand, the forms alluded to by Mr. Wachsmuth are of Carboniferous (or Subcarboniferous) age; whereas the true *Herpetocrinus* is confined to the Silurian. The three species as yet described in North America come from the Niagara group, corresponding to the English Wenlock, in which also the genus is well developed. *Brachiocrinus nodosarius* is from a higher horizon—the Lower Helderberg. But in Gotland, species of *Herpetocrinus* occur in beds of the same age, so that this presents no difficulty. On the contrary, the geological horizon is just what the appearance of the species would lead one to expect. It is a peculiarly developed species, more removed from what may be regarded as the ancestral form than are the species from lower horizons. Its cirri are distinctly curious, "composed of thick bead-like joints, which increase in size from the base to the middle, and thence diminish to the extremities." This character is possessed by only one other species of *Herpetocrinus*,

viz., *H. flabellicirrus*, which occurs in the uppermost beds of Gotland. In *H. flabellicirrus*, however, the character is correlated with the arrangement of the cirri in alternating fan-like groups. It may therefore be concluded, in the absence of evidence to the contrary, that the fossils described as *Brachiocrinus nodosarius* are congeneric with the species hitherto referred to *Myelodactylus* and *Herpetocrinus*, but that specifically they are distinct.

The name *Brachiocrinus* was published in 1859; *Myelodactylus* had been published in 1852; while *Herpetocrinus*, which is the only other name that demands consideration, was not published till 1873. If we are to follow the law of priority, without paying any attention to the various limitations proposed by the founders of that law, then all these species must —if I am correct as to the facts—be called by the name *Myelodactylus*. If, on the other hand, we accept only the more obvious among those limitations, then we shall attribute due value to the facts that *Myelodactylus* and *Brachiocrinus* were described in terms which anatomically considered were of absolute incorrectness; that, in consequence of this, the European paleontologist who first gave a correct description of *Herpetocrinus* could not recognize its identity with either of them; that for similar reasons the generic identity of the American and European species has been and still is denied by some American writers—I allude especially to Mr. S. A. Miller; that the most competent students of the Crinoidea in America refused to recognize either *Myelodactylus* or *Brachiocrinus*; and finally, that the names *Myelodactylus* and *Brachiocrinus*, being based on erroneous inferences, are essentially misleading. It seems to me that the zoologists, who, as at the International Congress, have recently been insisting on the absoluteness of the law of priority, under all circumstances, have overlooked the difficulties presented by fossils. Surely it is absurd that a name given to a complete skeleton should yield to some prior name given to a tooth or a tarsal, a feather or a fin-ray, especially since uncertainty so often attaches to the determination of their identity. Names that have been given to obscure fragments, and that, owing to insufficient description, have failed to gain acceptance, might well elude the stringency of the law. For such names at all events I prefer to accept the limitations proposed by the wise and ex-

perienced founders of the law of priority, and for the above given reasons I have adopted the name *Herpetocrinus*. The question, however, is one of minor importance so long as we understand the true facts of structure and affinity. Without further argument, therefore, I suggest the following revised diagnosis of

Herpetocrinus nodosarius:

Cirri (known as yet only in regions 5 and 6) irregular, alternating, at intervals of 1 to 4 ossicles; cirrus-ossicles moniliform, increasing in thickness distalwards to the middle of the cirrus, thence diminishing to the end. (Longitudinal sutures as yet unknown.) Distal end of the stem may form a bulb-like swelling, marked off by a slight constriction.

This diagnosis is congruent with those given in the "Crinoidea of Gotland," where all the terms here used are explained.

The bulb-like end is of interest, and confirms the view expressed in the following sentence:* "The attachment of the stem has not been seen in this genus. * * * * It is very probable that the animals usually broke off any rooted attachment they may have formed, and that they clung to corals or other submarine objects by their cirri. In some specimens the stem narrows at the distal end (plate II, figure 56); and this suggests that the creatures may have had some power of locomotion, such as might have been effected by successive contractions and extensions of the stem."

I have ventured to submit these remarks for publication in the AMERICAN GEOLOGIST, thinking that to be the surest means of attracting the attention of American students to these curious animals, about which, in spite of the investigations of many skilled observers, we have still so much to learn.

British Museum (Nat. Hist.), London, S. W., England.

DESCRIPTION OF A NEW GENUS AND FIVE NEW SPECIES OF FOSSILS FROM THE DEVONIAN AND SUB-CARBONIFEROUS ROCKS OF MISSOURI.

By R. R. ROWLEY, Louisiana, Mo.

ARISTOCRINUS, gen. nov.

Etymology, *aristos*, best; *krinon*, lily.

Fig. 1. Generic diagram. Fig. 2. *Aristocrinus concavus*, natural size.

Diagnosis.—Calyx forms a low cup and together with the short, thick arms has comparatively little hight. Basal region

*Crin. Gotland, p. 45.

concave. Underbasals, if present, hidden beneath the upper stem joint. Basals five, four of them being equal with acute angles above, the fifth truncate above. Primary radials three, —four in one ray of one example,—by five of unequal size, wider than long. Three of the first radials are heptagonal, while two are hexagonal. Secondary radials three in number. Two arms spring from the bifurcating plate of each secondary series of radials, making twenty free arms in all. Arms short and rather heavy, made up of single joints folded in or overlapping at the top. Short, strong pinules, apparently along the entire length of the arms but more crowded toward the ends. No so-called patelloid plates present in any of the specimens. A single, large, nine-sided interradial to each space except the azygous area. (The type specimen of *A. concavus*, instead of a single plate, has apparently some minute accompanying lateral plates which may really be fractured parts of the large plate.) The anal or azygous area is filled by three irregular plates accompanied by one or two smaller ones to the right and above. No appearance of an anal tube or proboscis. A single small, rounded, axillary plate rests between the first and second radial plates of the secondary series. Column moderately large, round and composed of even thin joints. Central perforation rather small.

This fossil occurs in the Hamilton beds of Callaway Co., Mo.

Type, *Aristocrinus concavus* (Rowley). The type specimen was first described by the author in the AMERICAN GEOLOGIST* under the name *Taxocrinus concavus*. Afterward other features were brought to light by the use of the knife, and in the same journal† other illustrations followed and the near relation of this crinoid to *Onychocrinus* was pointed out. Further study has led to the belief that it does not naturally belong to any known genus, and we have accordingly created a new generic term for its reception. It is evidently close to *Taxocrinus*, from which it differs in the shape of the calyx, the entire absence of the minute plates above the interradials and the possession of pinulæ, differing in this latter respect from all known ichthyocrinoids. In general outline *Aristocrinus* differs much from *Onychocrinus*, but, in the possession of pin—

*Vol. XII, p. 304, Nov., 1893.

†Vol. XIII, p. 153, March, 1894.

ulæ, reminds one of that genus with its short arms given off by the free rays. In case the name *Aristocrinus* should prove to be preöccupied our genus could be changed to *Callaway-crinus*.

ALLAGECRINUS AMERICANUS, sp. nov.

Fig. 3. Lateral view of the body. Fig. 4. Ventral aspect of the largest specimen in the collection, greatly magnified. Figs. 5 to 10. Other and smaller specimens very greatly enlarged, showing additional features.

Crinoid minute. Calyx conical. Basals form a low rounded cup. Number unknown, as the suture lines are not visible under a hand glass. Radials five, elongate, each with one or two distinct articular facets above for the attachment of arms. These scars directed upward but not noticeably outward. Arms unknown. The dome or ventral surface composed apparently of three single pieces, though the depressions around the vault suggest five. The left upper corner of one of the radials in several of the larger specimens meets the edge of the adjacent radial below the right upper corner of that plate and at first sight suggests an accidental break, but this may represent the anal area of other Paleozoic crinoids. The larger specimens with this feature present have scars for the attachment of nine arms, while the smaller examples have but five facets. A few thin round joints of a column have been observed attached to some of the specimens, and small, round stems are common in the clay. Plates apparently smooth. Most of the specimens are highly calcified so that features are made out with difficulty. The collection contains over three hundred specimens of all sizes, from those almost microscopic to those one-sixteenth by one-thirtieth of an inch, all possessing the vault in place.

Obtained from the clay partings between the two lower layers of the Lithographic or Louisiana limestone at the base of the Kinderhook group, Louisiana, Mo. The discovery of these little crinoids was made while washing clay for small brachiopods.

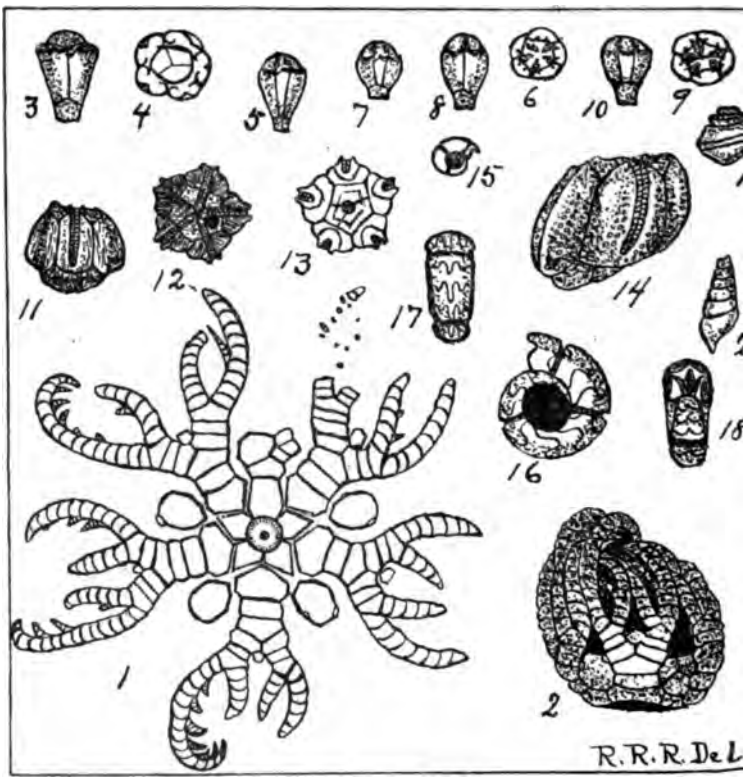
All the specimens collected correspond very closely with those figured by Dr. Carpenter as the young of *A. austini*, but nothing like his mature form has come under our observation and we are convinced that our larger specimens are adults. This little crinoid is especially interesting, both because it is

the second species of the genus from American rocks and al from its close relation to the only European species; mor over it is from a much lower horizon than Mr. Wachsmuth *A. carpenteri.*

GRANATOCRINUS (Schizoblastus?) MAGNIBASIS, sp. nov.

Figs. 11 to 13. Lateral, ventral and dorsal views of the type specime natural size. Fig. 14. Lateral view of a large distorted specimen, na ural size.

Body subglobose. Interradial areas greatly depressed s that the ambulacra and the bounding margins of the radial c fork pieces below stand out as five flattened ridges when th specimen is viewed from the base. Top of the body slightl sunken, so that it appears truncate above on a side viev That part of the base occupied by the column flattened. Bas plates form a very large pentagon, visible on a side view s the base is quite convex. The ambulacra do not extend to th



basal plates. The edges of the radial pieces and basal plates at their union form a slender double ridge, quite noticeable. The radial plates extend upward almost to the flattened top. Interradials occupy a space at the top larger than the area occupied by the basal plates at the other end. A slightly elevated double ridge follows the radio-interradial sutures, but no such elevation can be seen along the sunken radial sutures. Fine granular lines parallel to the ambulacra ornament the radial plates. The edges of the radials at the ambulacra are bent so abruptly upward as to appear to be bounded below by a suture. The ambulacra occupy less than three-fourths of the hight of the body, are very narrow with numerous pore pieces either side of the mesial furrow. The azygous interradial is little, if any, larger than the other four interradials. Anal opening rather large. Ovarian openings eight in number, rather small. Central opening uncovered in the specimens.

This blastoid may belong to Dr. Carpenter's genus *Schizoblastus*, as it seems to present some outward resemblance to it.

The collection contains nine specimens preserving the test and ten or more fine natural casts, some of which are larger than figure 14, all very striking fossils because of the great elevation of the ambulacral ridges which are extravagantly high above the sunken radials in the largest casts. One only of the casts is sub-elliptical in outline, while all the others eagre with the specimens figured, and all have a more or less distorted appearance, hardly accidental.

Collected from the upper Burlington limestone and the cherts of that horizon, just above the *Actinocrinus scitulus* horizon and consequently at the very base of the upper Burlington, in the quarries at Louisiana, Mo. Found associated with *Schizoblastus sayi*, *Physetocrinus ventricosus* and other well known upper Burlington forms.

GONIATITES LOUISIANENSIS. sp. nov.

Fig. 15. The largest specimen found, natural size. Figs. 16 to 18. Enlarged views of the same specimen.

Shell compressed, very small. Umbilicus large and rather deep, but the condition of the specimens is such that the inner whorls are not visible. Volutions rather slender and rounded on the dorsal side. Septa distinct only in a few specimens, probably on account of the pyritized condition of the shells. Dorsal lobe long, tongue-shaped and rounded at the end. Dor-

sal saddle hardly as long as the dorsal lobe, but wider, and rounded at the extremity. Upper lateral lobe shallow and rounded at the end. Lateral saddle shallow, broad and rounded. Lower lateral lobe broad, obtuse. From the umbilicus to the dorsal side of a volution, three well defined, equi-distant furrows extend. Body chamber not present in the specimen figured. The average size of the twelve or more specimens in the collection is little more than half that of the example figured.

Obtained from the clay partings between the lower two layers of the Lithographic or Louisiana limestone at Louisiana, Mo. Compare with Dr. A. Winchell's *G. pygmæus* from the Marshall group.

PLEUROTOMARIA MINIMA, sp. nov.

Fig. 19. Lateral view of a large specimen of the species, greatly magnified.

Outline of shell, low trochiform, minute. Volutions preserved rarely more than three, increasing rapidly in size. A narrow spiral band quite noticeable around the middle of the first volution. Suture well defined. Umbilicus small. Surface apparently ornamented by transverse lines, visible only on a single specimen. Aperture subcircular. Length and breadth of specimens about equal. One-seventeenth of an inch in diameter.

Collected from the clay parting between the lower two layers of the Lithographic or Louisiana limestone at Louisiana, Mo.

MURCHISONIA (?) PYGMÆA, sp. nov.

Fig. 20. Lateral view of a specimen greatly magnified. The figured specimen preserves six rounded volutions.

Shell minute, elongate, slender, tapering very gradually. Volutions rounded, the lowest being quite as long as the two whorls above. Suture well defined. No surface ornamentation visible, probably on account of the pyritized condition of the specimens, which after all may be but casts. Natural size of the figured specimen one-sixteenth by one-fortieth of an inch. A rare species.

Collected from the clay parting between the lower two layers of the Louisiana or Lithographic limestone at Louisiana, Mo. These shells were obtained while washing the clay for young brachiopods and were found associated with *Allagecri-*

nus americanus, *Pleurotomaria minima*, *Goniatites louisianensis*, *Ambocœlia minuta*, *Cyrtina acutirostris*, *Orthothetes lens*, *Chonetes geniculata*, *C. ornata*, *Spirifera marionensis*, *Spiriferina aciculifera*, *Productella pyxidata*, *Nucleospira barrisi*, and other well known Kinderhook species.

EXPLANATION OF FIGURES.

FIGURE 1. Diagram illustrating the arrangement of plates in the body and arms of *Aristocrinus*, a new genus of crinoids.

FIGURE 2. Azygous view of the type specimen of *Aristocrinus concavus* (Rowley): natural size.

FIGURES 3 and 4. Lateral and ventral views of the largest specimen of *Allagecrinus americanus*, sp. nov., greatly magnified.

FIGURES 5 and 6. Similar views of a medium sized specimen of the same species, highly magnified.

FIGURES 7 and 8. Side views of smaller specimens of the same species, greatly enlarged.

FIGURE 9. Ventral view of a large specimen of the same species, greatly magnified.

FIGURE 10. Lateral view of a medium sized specimen of the same species, greatly enlarged.

FIGURES 11 to 13. Lateral, ventral and dorsal views of the type specimen of *Granatocrinus* (*Schizoblastus?*) *magnibasis*, sp. nov., natural size.

FIGURE 14. Lateral view of a large distorted specimen of the same species, natural size.

FIGURE 15. Lateral view of the largest specimen of *Goniatites louisianensis*, sp. nov., natural size.

FIGURES 16 to 18. Lateral, dorsal and ventral views of the same specimen, enlarged.

FIGURE 19. A greatly magnified view of the type specimen of *Pleurotomaria minima*, sp. nov.

FIGURE 20. *Murchisonia ? pygmæa*, sp. nov. Type specimen, greatly magnified.

THE ELECTIVE SYSTEM AS ADOPTED IN THE MICHIGAN MINING SCHOOL.

By M. E. WADSWORTH, Director, Houghton, Michigan.

In this country two systems have been chiefly followed in the higher educational institutions,—the fixed and the elective. The latter was introduced first in this country by President Wayland, of Brown University, and it has since been systematized and developed with remarkable skill and success by President Eliot, of Harvard. Indeed, the system has proved to be so well adapted to the needs of modern times and to be so popular that it has made its way in the face of

a strenuous opposition, until all or nearly all of our colleges and universities have employed it for their work in general or literary and scientific education.

In technical or engineering education the case has been different, since even those schools, like Harvard, Stanford, or the University of Michigan, which have a most liberal elective system for general education, have still only a partially modified form of the rigid system in the engineering and technical courses. The rigid system is disguised in most institutions in their technical work under the head of election between various fixed courses, which may or may not have a few options, or it masquerades under an elective dress, to which it has but little, if any, right.

The elective system proper in any of the higher institutions giving general education has consisted of two features: first, the essential studies; second, the sequence of studies. The first is composed of those studies which are considered in each institution as necessary or essential to maintain the scholarship or traditions of the school in question, and in engineering schools, not even excepting that at Harvard, the required or essential studies to-day constitute the chief amount of the entire course in any of the engineering branches. In the case of general or literary education, the number of studies that are considered essential usually rapidly diminishes according to the experience and number of the faculty until only a few studies are required: and in time this feature will be fully eliminated.

Regarding the second, or "the sequence of studies," but little public attention is called to it in any statements relating to electives in any institution, although it is the keynote of them all. No school can maintain any elective system or any work above a kindergarten or primary grade, without carefully considering the question of the natural sequences. It is the unwritten law, that no student can take calculus who has not previously prepared himself in algebra, nor can he study petrography without any knowledge of mineralogy.

All the catalogues of the advanced schools show that they tacitly recognize the law of sequence of studies with greater or less fullness, but I do not know of any which call attention to the fact, except the recent prospectus of the Michigan Mining School.

In truth, the greatest curses, that beset any system of electives, are the neglect of proper sequences in the studies and the tendency of various instructors to bid for students, by giving weak and inferior (technically known as *soft*) courses. This last, like many of the other ills of educational institutions, can be partially, if not entirely, removed, by placing the charge of the instruction under one experienced executive head, which head is to be held strictly accountable for the success of the work, and is to be given absolute control over all the instructors, with power to discharge them if they do not properly perform their functions. In other words, there should be introduced into our schools more of the business methods of successful business houses,—the direct responsibility for, and power of the individual over, everything placed under his charge.

The Michigan Mining School has attempted to apply the methods in use in the elective systems employed for general or literary instruction to technical or engineering education, so far as the school's province of training men to assist in the development of the mineral wealth of the country will enable it to do. In accomplishing this it has tried to reduce to a minimum all studies to be taken by every student, to conserve the sequence, and to obtain thorough work by the business method of individual responsibility.

The only studies required of all the pupils here are "elementary geology" and the "elementary principles of mining," —these are asked for because it is believed that in any institution dealing with the problems relating to the mineral wealth the pupil should have some knowledge of geology and of mining methods, and also because the director (who in this case happens to be in charge of the geological instruction) desires to come into personal contact with every pupil in the school early in his course. The above mentioned studies require altogether the pupil's presence in the class room only three times a week for thirty-four weeks.

Outside of the elementary geology and mining the student is allowed unrestricted freedom of choice in his studies, the same as he is in the literary, but not in the engineering, work of Harvard, Michigan or in any other of our universities.

Emphasis is here placed upon the almost absolute freedom of choice at the Michigan Mining School because many have

mistaken the natural "sequence of studies" for "required studies." This error happens because in the prospectus of the elective system issued last May special attention was called to the natural sequences in chemistry, metallurgy, mechanical, electrical and mining engineering, ore-dressing and geology, provided any student wished to obtain every particle of instruction that is given in the school in any of the subjects named. These outline schemes are merely signs showing the student some of the numerous ways of reaching the upper rooms of the house, but he has absolute freedom to use any of the other numerous ways that might just as well have been pointed out. Owing to the fact that in the usual discussions of elective systems, the natural sequence of studies is not dwelt upon, it was expected that these guiding lines would be mistaken for required courses by many readers, although it was thought the error was sufficiently guarded against in the prospectus on pages 11, 13, 14 and 25. The precaution seems not to have been entirely successful, since a friendly hand in a friendly journal* has penned the following: "Students are allowed to select one of several courses with a certain principal subject, and in each course certain studies are required and the rest are elective. The school thus allows greater freedom in the selection of studies than do most mining schools." This friend has entirely misapprehended the facts, as the statements made above show. The freedom of choice is not only greater than that allowed in all other mining schools, but, so far as the present writer is aware, also greater than that in all other technical or engineering schools whatsoever.

Although this is the first time this general freedom has ever been allowed in any engineering school, the problem seemed to be so fully solved, so far as the special conditions of this institution are concerned, that when it was brought before the faculty and the board of control it passed both bodies without a single objection. The ostensible working of the system does not go into full effect until September 16th of this year, yet the choice of electives has already been made; and the passage of all the students from a rigid system to an elective one has been accomplished without any hitch or difficulty, but also with the pupils' unanimous approval.

*American Geologist, 1895, vol. xvi, p. 130.

The courses in operation up to the time of commencement, August 16th of this year, are two exceedingly rigid ones. The required work demanded of the student from seven to ten hours a day, five days a week for forty-five weeks a year, and for three or four years (according to which course was taken) in the class room, laboratory, field, mine or mill, while his daily preparatory work had to be attended to in outside time. When it is considered that all students, both special and regular, have been transferred, not only without trouble but with general satisfaction from one system to the other, the success seems almost phenomenal.

In the elective system of the Michigan Mining School the unit of work is taken as three hours a week in the class room or nine hours a week in the laboratory for thirty-four weeks, and this amount of work is called a course or a full course, while any subject scheduled in the prospectus for less time is taken for its proportionate part of a full course. The student, to obtain the degree of Bachelor of Science, must complete eighteen full courses, and to obtain that of Mining Engineer, twenty-two full courses, which in both cases include the subjects of elementary geology and mining.

Owing to the fact that the regular work in the Michigan Mining School extends through forty-five weeks of the year, a good student can obtain his degree in three or four years, depending upon the question of whether he remains during the entire forty-five weeks each year or for only the first thirty-four weeks, or, also, whether he wishes his course to be largely of practical or theoretical work.

At the present time this institution has announced sixty-five different subjects or studies from which the pupil can make up his eighteen or twenty-two full courses, only one of these full courses being of required work. In a required system of study the pupil can be carried over all the subjects that experience considers necessary for the successful prosecution of his future profession, but this is always done at the expense of thoroughness, and it pays no, or but little attention to the individuality of every student or to the rapidly increasing specialization of work in every subject. It gains breadth, but it is at the expense of depth.

In an elective system the individuality of the student, the specialization of work in modern times and the limitations of

human capacity are all considered. It loses in breadth, but it gains in the greater interest and consequently greater depth of the work done.

Much can be said in favor of both systems, as the writer knows from long experience with both; but there is one point that ought to be the controlling factor in every engineering school in deciding what it will do for the future. If the signs of the times and the history of education are read aright this is true and certain, that whether we like the elective principle or not, whether we are willing to adopt it or not, every engineering or technical school in the land must and will adopt it in its entirety, sooner or later, or else perish. It needs no Daniel to read the handwriting all over our walls.

ROCK HILL, LONG ISLAND, N. Y.

By JOHN BRYSON, Eastport, L. I.

(Plate XII.)

Rock hill derives its name from a huge boulder which crowns the summit of the ridge—the terminal moraine of geologists—about two miles north of the village of Eastport, on the Great South bay.

The boulder, though less than half its original size, is still a very respectable erratic, as may be seen by the picture accompanying this paper. It is a block of feldspathic granite, and the present measurement is about 50 by 20 feet. Judging from the size of the hole, which is partially seen to the left of the rock in the picture, from which the rock has been quarried, it must have been originally more than 125 by 20 feet. A good deal also has been blasted from the face of the boulder; one of the drill holes is visible at the feet of the figure on the top of the erratic.

Although exposed to the blasts from the ocean and the weathering of many centuries, some faint lines of glacial striæ can still be detected on the upper surface of this erratic block.

The moraine at this point is very fluviatile in character, only a few inches of loam covering the water-worn material, mostly quartz pebbles. It would seem at first as if the huge boulder had been dropped by floating ice, but a study of all the phenomena connected with it hardly permits this interpretation. It is not reasonable to suppose that icebergs would

have unloaded all their burden along the line of the terminal moraine, as no erratics of any size are found on the southern plain. Some of the advocates of floating ice have suggested that bergs would naturally become stranded on the higher elevations; and the absence of boulders between the two moraines seems to give weight to this suggestion, but as all the erratics have come from the north, why is it that the bergs which carried them did not become stranded on the northern moraine, the more elevated of the two? It is true that the boulders are more abundant on the north side of the island, but that some of them escaped gives us reason to suppose that a few would have been carried beyond the southern ridge, if floating ice was the means of transportation. That none were deposited in the valley between remains a mystery, no matter what theory we adopt; but the phenomenon is not peculiar to Long Island alone, as it has been noted in other glacial regions.

On the west end of the island, boulders, as a general thing, lie scattered in the valleys as well as on the ridges. It is only when we enter the Peconic depression, about opposite Port Jefferson, that the absence of boulders becomes conspicuous. This fact has led some glacialists to believe that the two ridges, separated by the Peconic valley, represent two distinct ice-sheets, but the present writer, after several years of careful study, can see no evidence of more than one. The connection of old river channels, with their effect on the whole contour of the island, precludes the dual theory; for that the streams flowing under the ice-sheet and advancing with it from the mainland had a great influence, not only in forming the valleys, but in giving shape to the hills, there can be no question, as I have tried to show in my paper on "The Ups and Downs of Long Island."*

The fact has been noted that opposite to the bay depressions, on the north side of the island, the terminal moraine becomes more broken and the glacial detritus is washed out in front of it and shaped into hummocky ridges or kames. To the north of Rock hill, on the sound, is the Wading river indentation, which cuts through the northern moraine, and the old glacial channels can be traced into the ponds and marshes of the Peconic valley.

*Am. Geologist, vol. xv, pp. 188-192, March, 1895.

It may be, as Prof. James D. Dana has somewhere suggested, that some of the boulders lie buried in the bottom of these ponds and marsh lands; but this is very doubtful, as erratics are absent on the higher intervening portions of land, at least so far as I have been able to observe. I have been over the ground on foot several times, and between Manor and Wading River, a distance of six miles, not a single large erratic was seen.

The island at this point is nearly fourteen miles in width. On leaving Eastport on the south you pass across a plain of stratified sand and gravel, covered with brush and stunted pines. About two miles this side of Manor, which is halfway between Eastport and Wading River, erratic blocks become quite plentiful, especially along the railroad track; and they grow larger and more abundant until the Manor station is reached. North of this, as you near the Peconic river, the boulders begin to disappear again, until the second moraine is reached about a mile and a half this side of the village of Wading River. The journey is very tiresome, as the road is a bed of loose white sand, with here and there a patch of clay and coarse gravel. The valley, however, consists chiefly of ponds and marshy depressions, as already stated.

From the terminus of the Port Jefferson branch of the Long Island railroad to the sound the hillsides are covered with huge boulders, nearly all from the same parent rock as the Rock hill erratic. Some of them doubtless contain more cubic feet, but none of them are so impressive in appearance.

It would be interesting to know if any of these large boulders were dropped in the bottom of this part of the sound, which is nearly opposite to New Haven, Conn. If none could be found, it would show that the boulders must have been distributed along certain lines or loops.

During my visits to Wading River I could detect no trap-rock blocks among the boulders; but they are found about two miles east of this point, and also on the southern moraine east of Rock hill, on the Culverton road.

The old channels of the Wading river depression unite, and seemingly end, with the Peconic river; but during the glacial floods the streams must have penetrated the terminal moraine at and in the vicinity of Manor, for we find the old channels



BOULDER ON THE SUMMIT OF ROCK HILL, LONG ISLAND.

indenting the ridge in many places. The Manor branch of the Long Island railroad runs through one of these waterways, with only a slight gradient from north to south. Very little cutting or filling in had to be done along this part of the route. We find that most of the old roads crossing the island run through these natural depressions in the terminal moraine.

It would never be suspected, perhaps, that this break in the ridge at Manor had anything to do in forming the river channel which is crossed by the south side railroad between Center and East Moriches; yet there is no doubt that a former connection existed. The writer has lately followed this depression up from the railroad to the ridge, and was surprised to find it uniting with other old channels that branch out from the Manor pass.

Where these breaks occur in the ridge the morainic material is generally pushed farther southward, especially between the arms of the old watercourses. Thus we find Rock hill coming down to within three miles of the bay, so that the boulder can be seen from the railroad at Eastport, if one knows where to look for it.

To the right of the picture can be seen one of the old river channels that broke through the moraine at this point when the glacial streams prevailed. Standing on the ridge by the boulder, one can see the course of the natural depression crossing the frontal plain to the Little Setuck river where it enters the bay. North of the Manor branch of the railroad where it unites with the main line, the channel is perfectly dry. South of it the water begins to percolate through the sand, and the swamp and marsh lands of the south side begin. A noteworthy kame is here developed and is referred to in "The Ups and Downs of Long Island," already mentioned.

The main branch of the Setuck river is crossed by the railroad a little farther east, and the original swamp lands, from which it had its rise, are covered with a beautiful sheet of water at Tuthill's mill. The old channel, however, of which the chart of the U. S. Coast Survey fails to give any proper idea, has been followed up by the writer through a tangled mass of brush to a large basin-shaped depression known as "Terrell's Hole." The channel becomes perfectly dry about a mile north of the railroad, and so is the kettle-hole depression:

yet no doubt a glacial stream at one time plunged into it, and the Eastport and Riverhead road seems to follow the old line of drainage.

On the north side of the moraine there is a beautiful sheet of water known as Great pond, nearly as large as lake Ronkonkoma and similar in origin. This pond and Terrell's Hole were doubtless at one time connected. How this connection could have taken place without a change of level we are at present unable to explain, but there is no evidence of oscillation, at least since the Ice age. It would seem as if the material was taken out of Terrell's Hole and dumped on the ridge near by to form Osborn's hill, which is said to be 293 feet above sea level.

It is a peculiar geographical feature of the island that the highest elevations rise along the line of these old watercourses. Dr. F. J. H. Merrill, in his paper on the "Geology of Long Island," has noted this fact, although he fails, we think, to understand its true significance. After referring to some of the higher hills, he says: "From these instances it will be seen that the areas of high elevation bear a very marked geographical relation to the deep indentations of the coast. That this relation is due to glacial action seems more than probable, and it can scarcely be an accidental coincidence that the highest hills on the island should be in line with the deepest bays on the northern coast and that the course of these bays should coincide with that of the glacier."* Dr. Merrill thinks that he sees in this phenomenon a confirmation of his ice-lobe theory, that is, he holds that the bay indentations have been plowed out by projecting spurs of ice, and that the higher elevations referred to are the result of lateral thrusts. A careful study of all the drift phenomena on the island will hardly bear out this interpretation. The present writer, in previous papers in the AMERICAN GEOLOGIST and other publications, has tried to show that not only the principal morainic ridges, but also the kames and the so-called sea beaches along the southern coast of the island were affected by glacial currents. On the beach opposite Eastport and Moriches the pebbles washed out by the waves of the sea are the same in character as those we find in the banks along the Long Island railroad, or on the

*Annals of the New York Academy of Science, vol. III, p. 360, Nov. 7, 1884.

summit of Rock hill, and they must have been brought there by rivers flowing from the mainland. I find a confirmation of this in a recent English publication, where a writer says: "Where pebbly beaches or cobble bars exist on ocean shores, they are generally near or at the debouchement of ancient or modern channels."*

The view from Rock hill is extensive and very beautiful. The Great South bay, with its fringe of beach and the ocean beyond, presents a delightful picture. In a clear day Fire Island lighthouse, nearly thirty miles away, can be discerned with the unaided eye. The vast frontal plain, with its wilderness of tangled brush, stretches out on either hand as far as the eye can see, giving a wild grandeur to the scene. Toward the east the moraine sweeps with a graceful curve to the Shinnecock range, whose brown hills are seen in the distance. Behind us the undulating ground tells of walls of ice and rivers of water, when the Ice King had sway; and on the crest of the huge boulder were written certain still legible lines of the history of his powerful reign.

GEOLOGICAL SOCIETY AND AMERICAN ASSOCIATION MEETINGS.

By WARREN UPHAM, Cleveland, Ohio.

GEOLOGICAL SOCIETY OF AMERICA.

The seventh summer meeting of the Geological Society of America was held in Springfield, Mass., on Tuesday and Wednesday, August 27th and 28th, 1895, under the presidency of Prof. N. S. Shaler, with an attendance of about forty fellows and friends of the Society. The meeting was in the beautiful new building of the Art Museum, then used for the first time. Dr. William Rice, secretary of the Library Association of Springfield, gave a cordial address of welcome. Memorial mention was made of Profs. James D. Dana and Henry B. Nason, fellows of the Society who have died since the last meeting; and biographic sketches commemorative of their work will be presented at the winter meeting. Eleven new fellows were announced as elected by the recent vote of the Society, namely, S. Prentiss Baldwin, Cleveland, Ohio, O. C. Farrington, Chicago, Ill., G. P. Grimsley, Columbus, Ohio, F. P. Gulliver, Norwich, Conn., J. B. Hatcher, Princeton, N. J.,

Edward B. Mathews, Baltimore, Md., John C. Merriam, Berkeley, Cal., H. B. C. Nitze, Baltimore, Md., F. L. Ransome, Berkeley, Cal., Charles Schuchert, Washington, D. C., and Joseph A. Taff, Washington, D. C. Philadelphia is to be the place of the next meeting, during the Christmas holidays.

Previous to this session, an excursion of a week's duration was taken, beginning at Pittsfield, Mass., and passing Hinsdale, Great Barrington, Mt. Washington, Mt. Race, Bear mountain, Salisbury, Canaan, Middlefield, Chester, Greenfield, Turner's Falls and Bernardston, all in Massachusetts, to South Vernon, Vt., under the leadership of Profs. B. K. Emerson and W. H. Hobbs. Sixteen fellows and invited friends participated in this most enjoyable observation and study of the metamorphic rocks and Triassic area of western Massachusetts and the Connecticut valley, namely, George H. Barton, Boston, Mass., Miss Florence Bascom, Bryn Mawr, Pa., A. C. Boyden, Bridgewater, Mass., W. B. Clark, Baltimore, Md., Miss Charlotte F. Emerson, Amherst, Mass., O. C. Farrington, Chicago, Ill., C. H. Hitchcock, Hanover, N. H., F. J. H. Merrill, Albany, N. Y., William Orr, Jr., Springfield, Mass., Chas. Palache, Berkeley, Cal., Joseph H. Perry, Worcester, Mass., William North Rice, Middleton, Conn., Miss Smith, Framingham, Mass., C. R. Van Hise, Madison, Wis., Lewis G. Westgate, Evanston, Ill., and Albert A. Wright, Oberlin, Ohio. The party traveled, as convenience dictated, by railroad, by livery carriages, and much afoot, to the localities where the contacts of different rock formations, faults and dynamic metamorphism could be best seen. The rich and varying development of secondary minerals along the lines of contact and disturbance was beautifully illustrated. The weather was perfect the whole time, with cool nights and mostly mild and clear days, having neither rain nor excessive heat. Admiration of the visiting geologists was freely expressed for the large area of complex crystalline rocks which during the past several years Prof. Emerson has mapped in detail for the U. S. Geological Survey, going afoot over all parts of a tract of about 5,000 square miles.

For notes of this excursion and of the meetings of this Society and the Association, aiding much in the preparation of the present report, the AMERICAN GEOLOGIST is indebted to Profs. A. A. Wright, I. C. White, J. F. Kemp (in his article on

the Geological Society meeting, in Science, vol. II, pp. 277-283, Sept. 6th), and to numerous authors who have kindly supplied abstracts of their papers.

Nineteen papers were presented before the Geological Society, but in several instances the authors were absent and their papers were therefore read only by title, for securing an early adjournment Wednesday noon. The following afternoon was spent in an excursion by thirty-seven fellows and their friends, with Prof. Emerson as guide, to Mt. Holyoke, to see contacts of the trap and sandstone and other features of the Triassic series. These papers in their order on the program, were as follows:

On the Glacial Deposits of southwestern Alberta, in the vicinity of the Rocky mountains. GEORGE M. DAWSON and R. G. MCCONNELL, Ottawa, Canada. (Read by title.) This paper presents the facts obtained during a recent examination of the glacial deposits of a portion of the southwestern part of the Canadian Great Plains, in the foot-hills and along the base of the Rocky mountains, where phenomena of particular interest are displayed in connection with the relations of the western and eastern drift (Cordilleran and Laurentide). A brief summary of previous observations is followed by a description of sections along two main lines of approach to the mountains at relatively low levels and by an examination of the conditions surrounding the glacial deposits at the highest levels, found in the form of terraces with rolled shingle at 5,300 feet on the Porcupine hills. In conclusion, the observed facts are briefly discussed, attention being practically confined to this particular region. [An article on the glacial drift of the same district by the same authors appears in the last number of the Journal of Geology (vol. III, pp. 507-511, July-Aug., 1895), in which the Kansan, Iowan and Wisconsin glacial formations are recognized in Alberta and Assiniboia, while for a still earlier till of western or Cordilleran derivation, with the associated Saskatchewan gravels, the name Albertan formation is proposed. The Kansan and Iowan till deposits of this region bear testimony, by the interblending of western and eastern drift, that the Cordilleran and Laurentide ice-sheets then became confluent along the east side of the Rocky mountains.]

The Champlain Glacial Epoch. C. H. HITCHCOCK, Hanover, N. H. The term *Champlain* was first applied by the author in 1861 to the marine deposits and associated fluviatile sands resting upon the glacial drift in the Champlain and St. Lawrence basins. Fifteen years earlier C. B. Adams pointed out the distinction which has become embodied in the terms *Leda clay* and *Saxicava sand*. These deposits contain 240 species of fossils in the St. Lawrence valley, nearly all of which are identical with forms now living off the Labrador coast. The same is true likewise of the 121 species catalogued from the corresponding deposits

at Portland, Maine. The preglacial southern limit of this boreal fauna seems to have been a little north of Boston; but its presence later was indicated also at Nantucket Island, in the upper shell bed of Sankaty Head, where the summer temperature was fifteen degrees (Fahr.) colder than in the lower beds.

Northern areas were depressed more than those toward the south, the vertical extent of the Champlain subsidence, below the present altitude, having been 50 to 75 feet near New York city, 300 to 400 feet in Vermont and 560 feet at Montreal. This leads to the belief that the stratified clays in the valleys of our northern rivers, like the Connecticut, were deposited during this epoch; and the occurrence of Arctic plants in them strengthens this view. At the same time the Laurentide, White, Green and Adirondack mountains were covered by local glaciers which sent bergs into the enlarged gulf of St. Lawrence, giving to it a severely cold climate. Ice floes and bergs from Arctic regions must also have entered the Champlain sea, as many of the smaller bergs borne southward by the Labrador current do now; but far more abundantly than at present, because of the greater depth of the water in the Strait of Belle Isle.

Marine submergence is suggested for all the area of the great Laurentian lakes, as far as to lake Superior and Minnesota, by the presence there of still living maritime plants, fish, and crustacea. These plants and animals appear to require the former presence of the ocean to account for their geographic distribution. The glacial conditions of the Champlain epoch would correspond to the history of the Canadian Ice Age, as that is presented by Sir William Dawson, who asks only for local glaciers, moderate submergence in the St. Lawrence basin, and an Arctic current, to explain all the phenomena which he has observed. Hence the advocates respectively of icebergs and of land ice as the chief agency of formation of the drift may harmonize their views by conceding, each to the other, an additional cold epoch. By doubling the Ice Age, each side can retain its own pet theory and yet allow its opponent the same privilege.

The occurrence of 55 species of temperate fossil shells in the till of drumlins near Boston proves the existence of a mild preglacial climate and of an ensuing ice-sheet extensive enough to pile up the largest of our grand moraines and drumlins, probably amassing these marginal and submarginal drift deposits during the Champlain epoch.

The Mecklenburgian stage in the Glacial period, as described by Geikie for Europe, has the following points in common with the Champlain epoch in America: first, marine fossiliferous clays, with Arctic mollusca; second, fluviatile clays, with leaves of Arctic plants; and third, the deformations of the earth's crust which have been studied by De Geer both in Sweden and North America. If the Mecklenburgian stage is necessarily the equivalent of the Wisconsin, the moraines of all the northern United States and Canada may be referable to the Champlain epoch of land depression and consequent departure of the ice-sheet, which was represented finally by many local glaciers.

Much discussion followed this paper. Prof. WHITE had wanted still water, as of the Champlain submergence, to explain the terraces of the Monongahela valley. Prof. KEMP cited the barrenness of the clays in the Hudson valley as to all organic remains, excepting a few diatoms, and remarked that the variety of fossils is small in the Champlain valley. Prof. J. W. SPENCER called attention to the moderate elevation of the Laurentide mountains, so-called, and noted other topographic features of the St. Lawrence basin. Prof. DAVIS said that a criterion of a marine terrace would be steady uniformity of level, not varying with the inclination of the stream, and that the Pennsylvania and West Virginia terraces are thereby shown to be of fluvial instead of marine origin. President SHALER suggested that the lack of fossils might be caused by the decay of organic matter in the clays, which would develop gases and destroy them. Prof. HITCHCOCK, in closing the discussion, said it was hard for him to understand why the Hudson valley and that of lake Champlain are not more alike in this respect, since no high barrier separated them. The view taken by Upham gives to the land about the mouth of the Hudson even a somewhat higher altitude throughout the Champlain epoch than now, so that a glacial lake in the Hudson and Champlain valleys outflowed there to the ocean; but he thinks that the Hudson valley had become much uplifted northward from the Champlain depression before the continuing glacial retreat admitted the sea to the St. Lawrence and Champlain valleys.

Drumlins and Marginal Moraines of Ice-sheets. WARREN UPHAM, Cleveland, Ohio. (Read by title.) Field studies of drumlins in New Hampshire, northeastern Massachusetts and New York, and of marginal moraines in New England, Long Island, Minnesota, Iowa, the Dakotas, and Manitoba, supply explanations of their origin from previously englacial drift. The drumlins are shown to have been amassed from a sheet of till which had become superglacial by ablation, but which afterward by glacial overflow became enclosed in the ice-sheet and finally was heaped in these oval or more elongated smooth hills of subglacial till. The moraines are referred to pauses in the Champlain recession of the ice-sheet, when its currents were accelerated by steeper gradients and much warmer climate than during the earlier stages of ice accumulation and maximum glaciation. Both in North America and Europe the marginal moraines and drumlins are attributed chiefly to the Champlain epoch, that is, the short and definite closing part of the Ice age.

The Glacial Genesee lakes. H. L. FAIRCHILD, Rochester N. Y. The direction, inclination and extent of the Genesee valley made possible the production, during the retreat of the ice-sheet, of a succession of glacial lakes with different outlets. The paper described, with the aid of a map, (1) the present topography and hydrography of the valley, (2) the ancient drainage channels, (3) the complex lacustrine phenomena. Ten stages in the gradual uncovering of this area from the ice-sheet were traced, of which the eighth, with beaches and deltas at 900 to 910 feet above the sea, was regarded as the time of the glacial lake Warren; the

ninth was that of glacial lake Iroquois; and the tenth is the present time.

This paper was discussed by I. C. WHITE, N. S. SHALER, J. W. SPENCER, W. M. DAVIS, and H. S. WILLIAMS.

The Geology of Old Hampshire county in Massachusetts. B. K. EMERSON, Amherst, Mass. Twenty minutes were first given to a description, with detailed maps, of the crystalline rocks which form the western and eastern borders of the Connecticut valley, in which Springfield is situated, for the use of the members of the Society on excursions in the vicinity.

Again, twenty minutes were occupied in a description of the Triassic strata of this valley and the history of their origin, involving the filling of the basin with sands and gravels, the outflow of trap and the eruption of ashes, closing with the formation of a series of small volcanic cones, and followed by the upfolding and erosion of the whole. This part of the paper was illustrated by maps and models.

Lastly, in the third twenty minutes of the hour, the Glacial and Postglacial history of the region was reviewed, with exhibition of detailed maps of the glacial lakes and river courses antedating and following the formation of the great series of lakes which occupied the present Connecticut river valley, and maps of the later terraces formed in the old lake beds. The way in which the alluvial plains are made up of confluent islands was explained; and attention was directed to the distinction between filled and unfilled lakes, the old Springfield lake having become filled, while the Hadley lake remained unfilled. The further facts were noted that tributaries run down directly across the old bottom of unfilled lakes, but when they come upon the broad terrace flat or meadow there appears a marked repulsion of the tributary from the main stream, so that they flow parallel with each other for long distances, after which the affluent finally turns and enters the trunk river at right angles. This was explained by the formation of islands in the main stream off the mouth of the tributury, so that the latter had to flow around the islands down stream one after another, thus running parallel a long way before reaching its mouth.

The many oxbows and big bends of the Connecticut, and of its tributaries, across the bottom of unfilled lakes, were adduced as indications of the influence of the earth's rotation.

Notes on the Relations of Lower Members of the Coastal Plain Series in South Carolina. N. H. DARTON, Washington, D. C. (Read by title.) The formations below the Eocene buhrstone, which were included in the Eocene by Tuomey, have been found to be Potomac. Some of their features and their relations to the marine Cretaceous are described.

Resumé of general Stratigraphic Relations in the Atlantic Coastal Plain from New Jersey to South Carolina. N. H. DARTON. (Read by title.) A series of sections was announced to accompany this paper, showing the distribution and variations of the principal coastal plain formations.

Cretaceous Plants from Martha's Vineyard. Results obtained from an examination of the material collected by David White in 1889. ARTHUR HOLLICK, New Brighton, N. Y. At the New York meeting of this Society in December, 1889, Mr. David White read a paper on this subject which was published in abstract in the proceedings of that meeting. Mr. White subsequently published a more extended account in the American Journal of Science for February, 1890, and figured a few of the specimens which were most readily to be identified as Cretaceous species. These papers were based upon material collected by him and Mr. Lester F. Ward during the summer of 1889. Their object was principally to demonstrate the occurrence of Cretaceous strata in that island, hence only sufficient material for that purpose was utilized. During the present year all the material which was collected has been turned over to Mr. Hollick for examination and report, in addition to which are a few specimens which he collected in 1893. All these collections indicate a flora parallel with that of the Amboy clays in New Jersey. The fossil leaves are found in concretionary sandstones which occur with the clays of Martha's Vineyard in somewhat uncertain relations; so that it is very desirable, if possible, to obtain such fossils also in the clays. The difficulty of preserving the leaf impressions hitherto found in the clays has prevented their study.

On the Eocene Fauna of the Middle Atlantic Slope. WILLIAM B. CLARK, Baltimore, Md. According to the author's studies, the Eocene fossils of New Jersey and the country southward to North Carolina should not be referred, as formerly has been done, to one, or a part of one, of the seven divisions of the Eocene based on the Gulf localities. The glauconitic beds were of slow but continuous growth, not burdened with detritus, and 200 feet of this greensand formation may easily be the time equivalent of 2,000 feet of Gulf deposits. Prof. Clark has found 120 species of fossils instead of the previously known 25, and they generally range well through the whole of the series from bottom to top, though some are characteristically lower or upper. They agree well with those found in both the Lignitic and the Claiborne beds, at least; and many of them probably endured through the entire Eocene period.

Arrangement and Development of Plates in the Melonitidæ. R. T. JACKSON and T. A. JAGGAR, Cambridge, Mass. This paper consisted in a statement of the arrangement of the plates in these spheroidal echinoderms, and especially of the way in which new rows of plates are introduced and die out. Whereas it had formerly been supposed that in the interambulacral areas new rows of plates originate near either pole, and spread meridionally, meeting in the equator, Dr. Jackson showed that new rows originate near the oral pole only, often in a heptagonal plate, the rest of the plates being six-sided; that the rows are extended toward the genital plates at the aboral pole, where the crowding of the plates gives them an irregular arrangement; and that new rows are introduced alternately upon the right and left sides of the interambulacral area, beginning near the oral pole and near the central meridian of

an interambulacral space. The two boundary rows of an interambulacral area are derived from the two initial plates of that area which belong to the peristomial ring; while the intermediate meridional rows up to the number of six (the total number af rows thus being eight) originate in the place and manner here described.

Prof. ALPHEUS HYATT commented on this paper, that it is a very valuable contribution to the life history of the family and the class, and also to the general subject of evolution.

On Asbestos and Asbestiform Minerals. GEORGE P. MERRILL, Washington, D. C. (Read by title.) The author treats of the composition, mode of occurrence and mineralogical nature of the various minerals commercially grouped under the name of asbestos, and attempts to explain their fibrous structure as due to abnormal elongation of the mineral parallel to the vertical axis, the individual fibers being in part at least bounded by prismatic faces, that is, by the planes of easiest cleavage. The primary cause of this elongation is believed to be mainly dynamical, a result of shearing and other earth movements such as are productive of uralitic hornblendes, schistosity, or even platy structure and slickensided surfaces where actual fracturing takes place.

Pre-Cambrian Volcanoes in southern Wisconsin. WILLIAM H. HOBBS, Madison, Wis. A preliminary report on a group of isolated areas of igneous rocks which protrude through the Potsdam sandstone in the valley of the Fox river, Wisconsin. Some of these areas represent local outflows of rhyolitic lava which exhibits superb examples of spherulitic, perlitic, fluxion, and breccial structures. The originally glassy ground mass of these rocks has become devitrified—hence they are apo-rhyolites, and they have been subjected to dynamic metamorphism and subsequent infiltration of silica. They are intruded by dikes of both basic and acid rocks. (Specimens and photographs of sections were exhibited.)

A Geological Sketch of the Sierra Tlayacac, in the State of Morelos, Mexico. A. CAPEN GILL, Ithaca, N. Y. The Sierra Tlayacac, some six miles long, situated on the south side of the great fault-line described by Felix and Lenk, consists of a projecting group of mountain tops in the midst of the Morelos plain. The plain is formed by the lava streams and ejectamenta of Popocatepetl or neighboring volcanic vents. The tops of the nearly submerged mountains show that the folding and elevation of the Cretaceous (Caprina?) limestone was accompanied or followed by the deposition of a limestone conglomerate, in the pebbles of which are also Caprina (?) fossils. Absence of pebbles derived from eruptive rocks indicates that the volcanic activity of the region was subsequent to extensive folding and erosion.

The limestone agglomerate is overlain by an acid eruptive, and both rocks are cut by numerous quartz-pyroxene dikes which show a close "consanguinity" with the recent extrusions of Popocatepetl. The very striking metamorphism produced by these dikes corroborates the view that there is little, if any, migration of material from the intruded mass into the metamorphosed rock.

Heated water and steam would appear to be the principal agents of metamorphism, rather than heat alone, since the great distance to which recrystallization has reached seems dependent on the *porous character* of the rock before alteration. Garnet, vesuvianite, wollastonite and pyroxene are among the minerals developed, and large crystals have been found at a distance of several hundred feet from the contact.

Prof. EMERSON, in discussion, complimented the author on his having modestly refrained from proposing new names for these eruptive rocks.

Syenite-gneiss (leopard rock) from the Apatite Region of Ottawa county, Canada. C. H. GORDON, Beloit, Wis. (Read by title.) The rock here described appeared in the exhibit of the Canadian Geological Survey, at the World's Fair, under the title of "Concretionary Veinstone," from the apatite region. It consists of irregular ellipsoidal or ovoid masses of feldspar, with some quartz, separated by narrow, anastomosing bands of interstitial material consisting chiefly of green pyroxene. The ellipsoidal masses are of all sizes up to two or three inches in cross section and several inches long. The field study at High Rock mine, Ottawa county, shows the rock to occur in dikes intersecting the pyroxenites and quartzites. In some places the rock is very coarse, with no indications of the ellipsoidal structure, while in others it is a distinctly banded gneiss whose identity with the ellipsoidal rock is evident from the anastomosing of the augite bands on a cross fracture face. Ordinarily the rock has very little quartz and corresponds to a pyroxene-syenite, but in some places the quartz is much more abundant, thus allying it to the pyroxene-granites. In view of its gneissic structure and usually sparing amount of quartz, the rock is here referred to generally as syenite-gneiss, though grading locally into forms which may more fittingly be regarded as granite-gneiss.

The presence of a distinct gneissic microstructure, taken in connection with other facts, appears to establish the conclusion that the peculiar ellipsoidal structure is due to orographic forces acting upon a coarsely crystallized rock in which the principal constituents (feldspar and pyroxene) are more or less irregularly distributed. The breaking of the rock under pressure has been attended by the recrystallization of the augite and other constituents along the original fracture planes, which were probably, in part, determined by the arrangement of the two chief constituents.

The points of interest brought out in the study are: (1) that this peculiar distribution of the pyroxene is due to dynamic processes, (2) the importance to be attached to the process of solution and recrystallization in the formation of gneisses, (3) the significance of the original character of the rock with reference to the product derived from it by dynamic processes, and the differences resulting from variations in the extent to which it has been affected by orographic agencies, and (4) the evidence showing the derivation of a gneiss out of a syenite, and establishing the term syenite-gneiss as the name of a distinct rock type.

The Titaniferous Iron Ores of the Adirondacks. J. F. KEMP, New York City. The paper opened with a brief statement of the characters

of the two kinds of iron ores which are afforded by the region, the merchantable magnetites and the titaniferous. The former are in gneisses; the latter in the gabbros and anorthosites of the Norian, which are believed to be intruded through the gneisses. A list of localities of the titaniferous ores was given and the distinction was made between the smaller bodies which are, so far as can be seen, basic developments of gabbro, and the enormous ore bodies at the old Adirondack Iron Works in the heart of the mountains. These latter are in massive anorthosite, which is almost entirely formed of large, blue-black crystals of labradorite. The largest ore body, which is the one crossing Lake Sanford, contains numerous included labradorite crystals, each of which is surrounded by a reaction rim 5-10 mm. across. It is further noted that the wall rocks show no signs of the widespread crushing that is exhibited in the general "mortar-structure" of the Adirondack and Canadian anorthosites, but are plutonic rocks, free from evidences of dynamic metamorphism. The argument is then made that the ores are segregations from an igneous magma formed during the process of cooling and crystallization. In conclusion the speaker gave some notes on recent attempts to utilize the titaniferous ores that bid fair to be successful.

In discussion, Prof. VAN HISE mentioned the similar bodies of titaniferous ores in the gabbros of lake Superior, adding, however, that there had been some infiltration of iron oxide since their formation.

The Decomposition of Rocks in Brazil. J. C. BRANNER, Stanford University, Cal. The deep decay of rocks in Brazil is notorious, though but few observations have been published on the subject. The present paper embraces the results of the author's observations made during the eight years he lived and traveled in that country, together with the statements of other geologists. The evidences of deep rock decay are found in railway cuts and tunnels, excavations in hills in Rio de Janeiro for buildings and for a reservoir, deep mines in the gold region of Minas Geraes, in enormous gullies of recent origin, and in numerous landslides. Many instances of decomposition to a depth of more than 100 feet are known, and in some of the old gold mines the rocks are soft to a depth of more than 300 feet. This decomposition seems to be widespread, though not universal, in Brazil.

Exfoliation is a common feature, and is not confined to boulders; massive rock hills and mountains exfoliate in the same way as the boulders of decomposition. Some of the peculiarities of the topography in the granite and gneiss regions are due to this method of decomposition. Talus slopes are very rare. Massive rocks sometimes weather into fluted surfaces, having steep-sided trenches and ravines that run straight down the rock faces.

The chief mechanical agency promoting rock decay is change of temperature within a range of about 100° Fahr. But little direct work is done by this agency, and its chief importance lies in the fact that it opens crevices that admit the chemical agencies of decay, gases, water and acids, which destroy the rock rapidly. Color is believed to be of some influence in this connection, as the black crystalline rocks are sel-

dom or never found naturally exposed on account of their more rapid absorption of heat.

Burrowing animals, especially ants and termites, contribute much to the chemical agencies of rock decomposition. The soil of Brazil is fairly alive with these insects; their burrows penetrate to a depth of ten or twelve feet and radiate on all sides. Into these openings they carry plant food, and the acids from their decay and from the breath of the insects help to hasten the decay of the rocks below.

Vegetation in the tropics is notoriously abundant and rank; the decay of so much organic matter in a hot and moist climate produces large quantaties of humus acids that attack the rocks into which they are carried by the rains. The amount of carbonic acid carried to the earth is calculated from determinations of it in rain water and from the rainfall in that country. Nitric acid, produced by electric discharges, falls in larger quantities in Brazil than in the temperate regions of the earth. The amount of acid to the litre of water has been determined from direct observations, and this with the rainfall furnishes the data for determining the total precipitation of nitric acid.

The annual rain fall of Brazil ranges from about three feet at Rio de Janeiro to seven and a half feet at Manaus on the Amazon, and almost twelve feet on the mountain near Santos. This great precipitation is not distributed throughout the year as it is in temperate regions, but is concentrated for the most part within less than six months. The long dry season dries the ground out so that enormous cracks are opened in places to depths of ten or fifteen feet. Air circulates freely in these openings, and when the rains come organic matter in large quantities is washed into the crevices and the acidulated waters reach considerable depths very promptly.

The Bearing of Uniformity on Uniformitarianism. W. M. Davis, Cambridge, Mass. When a theory accounts not only for the facts that it was made to explain, but as well for a number of facts that were unknown at the time of its suggestion, its correctness is doubly confirmed. The early British geologists, who proposed to explain the past history of the earth by processes of the same order as those in operation to-day, had the general problems of denudation and deposition in mind, but they knew nothing of several special problems of denudation that are encountered in the study of rivers. Even Lyell defended the marine origin of the cliffs of the Weald in southeastern England. The doctrine of uniformitarianism successfully routed the hypotheses that explained valleys as the work of ocean currents during a time of submergence, or as the result of fractures in the earth's crust; but the British school, by whom this doctrine was so ably advanced, did not carry it to to the extreme application of accounting for the migration of river divides and the associated adjustment of river courses to rock structures. A few British writers have touched this problem, but none of them have penetrated it. European and American geologists have the chief credit of its solution.

The deepening of young valleys by the ordinary action of streams is a comparatively slow process, and the wasting of valley sides under the

attack of weather and water is still slower; but the migration of headwater divides by the unequal wasting of their slopes is the slowest of all. The occurrence of river arrangements that are indisputably due to this excessively slow process of migration is therefore strikingly confirmatory of the doctrine of uniformitarianism. The fundamental principles of uniformitarianism are the postulates of the theory by which the spontaneous adjustment of river courses to rock structure is accounted for. The success that has been reached in explaining this class of natural phenomena confirms the correctness of the postulates on which the explanation is based.

Prof. EMERSON, in discussion, cited instances of the robbing of one stream's headwaters by another in the relations of the Housatonic and Connecticut divides in western Massachusetts; and President SHALER spoke of the influence of continental tilting in bringing about such changes of drainage.

Analysis of Folds. C. R. VAN HISE, Madison, Wis. As regards movement, three zones in the constitution of the earth were cited, namely, an outer zone of fracture, an inner of fracture and flowage, and an interior one of flowage alone. The thickness of the upper zone, which is characterized by faults, will vary with the rocks. Quartzites and limestones, being relatively unyielding, would give the zone great thickness; but the more yielding shales and schists flow at a small depth. Folds are ordinarily considered as simple flexures in two dimensions, but in nature folds are compound flexures in three dimensions. The analysis of simple folds given by Margerie and Heim was summarized. For the sake of simplicity, folds were first treated in two dimensions. A composite fold is produced by the combination of various simple folds. Composite folds include both normal composite folds and abnormal composite folds. The genesis of each was discussed and each was classified into upright, inclined, and overturned anticlinoria and synclinoria.

When composite folds are cross folded, these are called complex folds. The character and origin of complex folds were discussed. Rules were given for observations in regions which are folded in a complex manner, and the use of folds in the discovery of unconformity and the secondary changes which accompany folding were summarized.

Prof. DAVIS, referring to the three zones, asked whether the speaker could estimate from the character of the flowage or fracture, shown by an eroded fold, whether much or little original burden of rock had been removed; and Prof. VAN HISE, in reply, stated that he thought it could be done within reasonably wide limits, as within probably two to five thousand feet.

Conditions and Effects of the Expulsion of Gases from the Interior of the Earth. N. S. SHALER, Cambridge, Mass. The aim of the paper was to show that the phenomena of escape of gases from the earth in the case of ordinary springs, in the ejections of water which occur in earthquakes, and in the explosions which take place in volcanic eruptions, all rest on the same general basis. The column of ascent is determined by the formation of bubbles in substantially the same way in

which the action may be seen to take place in any fluid which is charged with carbonic acid. The discussion of the temporary springs termed in the paper earthquake fountains, or shock fountains, was directed to show that in these colums of ejection the law of ascent of the gases is essentially the same as that observable where gases pass upwards in fluids, a weak line being made by the formation of a bubble which in rising induces the formation of other bubbles by diminishing the pressure along the line of its ascent.

Some attention was given to springs formed in the alluvial mud of delta deposits; and it was shown that these springs have had their paths of escape determined by the gases which impel the waters upward. This was noted as particularly plain in the case of the "mud lump" springs of deltas.

The main point of the paper was that volcanic outbreaks, being essentially vapor outbreaks, can be placed in the series with the other groups of gas ejections. Observations on an eruption of Vesuvius in 1882 were used to show that the exploding vapors escaped in the form of large bubbles which were segregated from the lava. Reference was also made to the probable influence of this action in the formation of the "chimneys" of ore-bearing veins.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The American Association for the Advancement of Science also met in Springfield, Mass., holding its forty-fourth meeting from Wednesday, August 28th, to the following Wednesday, September 4th, under the presidency of Prof. E. W. Morley, of Cleveland, Ohio. The retiring president, Dr. Daniel G. Brinton, was unexpectedly detained in Europe; but his address, "The Aims of Anthropology," was read before a large audience on Thursday evening.

The next evening a public lecture, complimentary to the citizens of Springfield, was given by Prof. William M. Davis, entitled "Geographic Development of the Connecticut Valley," with lantern illustrations. Three chief features or stages of the growth of the New England highlands and this valley were noted: first, the old mountain ranges worn down; second, the "monadnocks" left, as remnants of the former mountain masses, not wholly worn away; third, the slowly uplifted highlands and the streams cutting through them. Narrow portions of the valley occur where the material cut down by the stream is hard, as the trap ridges in some places adjoining the Connecticut river; while elsewhere the valley is broad, because the rocks are soft and worn away easily, as the Triassic sandstone. Views similar to those along the Connecti-

cut were also shown of the part of Germany through which the Rhine flows, illustrating how that stream likewise has cut down its channel as fast as the highland country has been elevated.

On Saturday many members of the Association, braving a rain storm, went in an excursion to Mt. Holyoke Seminary in South Hadley, to Amherst College, and to Smith College in Northampton. The very extensive ichnological collection and other paleontological, mineralogical and geological collections of Amherst College were much admired. Another excursion was taken on Tuesday by the geologists, under the leadership of Profs. W. M. Davis and Wm. North Rice, to Meriden and Southington, Conn., for observation of the Triassic sandstone, lava flows, faults, and planes of contact with the older crystalline rocks.

The enrolled attendance of the meeting numbered 367, and the list of 183 new members elected brings the total membership of the Association up to 1,980.

Section E (Geology and Geography) held its sessions in the Art Museum, with Major Jed. Hotchkiss, of Staunton, Va., vice president, and Prof. J. Perrin Smith, of Palo Alto, Cal., secretary. The address of Major Hotchkiss, owing to his lateness of arrival, was deferred to Monday afternoon. It was entitled, "The Geological Survey of Virginia, 1835-1841. Its History and Influence in the Advancement of Geologic Science." The Virginia survey, chiefly by William B. Rogers, preceded that of Pennsylvania by the same geologist with his brother, Henry D. Rogers. Virginia, however, failed to publish the work that was done. It still is recorded in the fifty note-books, besides maps and files of letters, which are now in the possession of Major Hotchkiss; and he is preparing a typewritten copy of all the important parts of this pioneer survey.

For next year, Prof. Edward D. Cope was elected president of the Association; and, in Section E, Prof. Ben. K. Emerson, vice president, and Prof. A. C. Gill, of Ithaca, N. Y., secretary. Buffalo, N. Y., was chosen as the place of the meeting; and, after much discussion, its time was decided to be from Monday, August 24th, to Friday, the 28th, so that all the reading of papers and business shall come during consecutive

days of a single week, instead of being interrupted, as heretofore, by the excursions of Saturday and the rest of Sunday.

Eighteen papers were read in Section E, as follows:

The Relations of Primary and Secondary Structures in Rocks. C. R. VAN HISE, Madison, Wis. Cleavage was distinguished from fissility. A slate or a schist may have both, and they may be parallel or inclined to each other. The metamorphosed rocks have secondary structure imposed upon them, whose lamination rarely corresponds with the bedding. The difficulties of determining the true thickness of such beds is great, and highly exaggerated estimates have often been made in sections of the ancient crystalline rocks.

The Archæan and Cambrian rocks of the Green Mountain Range in southern Massachusetts. B. K. EMERSON, Amherst, Mass. The main purpose of the paper was to bring to the notice of the audience a manuscript geological map of the south central portion of Massachusetts from the Housatonic valley to the eastern border of Worcester county. The author described in some detail several typical outcrops of pre-Cambrian rocks which lie along the western rim of the Green Mountain belt as it crosses Massachusetts.

The Hinsdale area was described as one where the pre-Cambrian rocks occur in crescentic bands. The oldest rock is the Hinsdale gneiss in the center, and this is surrounded by the coarse Hinsdale limestone, the Lee gneiss, and the Washington gneiss, in succession. It was shown how the unequal wear of the pre-Cambrian formations had produced the upper part of the Westford river pass.

The Tyringham area was described as giving evidence of an old pre-Cambrian land with east to west folds beneath the north to south Green Mountain folds. Erosion of pre-Cambrian limestones has formed the deep East Lee valley and the basins of many small lakes. In the Bear Mountain-Monterey system of V-shaped overturned anticlines, each fold of a numerous parallel series is bent sharply, so that the front bed may be compared to the double concave surface of a railroad snow-plow.

Tracts of crystalline rocks east of the foregoing, with prevailing north to south trend, were briefly characterized, beginning with the pre-Cambrian rocks and ending with the Upper Devonian crystallines of Bernardston. Attempts are being made toward a correlation of the crystallines east of the Connecticut river with those on the west. The schists of Worcester county, with their abundant granites, were also described, with indication of their relations to the probable pre-Cambrian area of Sutton and Douglas in the southeastern part of this county. The opinion was expressed that probably some of the granites on both sides of the Connecticut river are of Carboniferous age.

One interesting special point was the description of the stretched quartz pebbles in the conglomerate gneisses at Woonsocket, R. I., and elsewhere. Their present dimensions in some cases are 18 by 4 by 2 inches.

Gotham's Cave; or Fractured Rocks in northern Vermont. C. H. HITCHCOCK, Hanover, N. H. This cave, or rather series of caves, situated on the west side of Norris hill in Maidstone, Vt., extends about 1,000 feet up and down the slope of the hill in a nearly easterly and westerly direction. It lies in mica schist and comprises really three distinct caverns, marking the course of a fracture or series of fractures which resulted from sudden movements of the earth's crust under the stress of lateral pressure. The caverns probably extend farther and deeper than they have been explored. Many of the passages are closed by fragmental rocks; fissures are numerous and extend in many directions. Several of the chambers may be regarded as cross-fractures, the general appearance of which would seem to indicate that they originated at the same time and in the same manner. In almost every case the walls of the passages are found to match nearly, but the south side is invariably a foot or more lower than the north wall. In the third chamber ice and snow may be found in the summer months. This is one of the largest caverns, being 16 by 20 feet, and 15 feet deep. From some of these passages blasts of air that will blow out a candle flame are constantly issuing.

Recent Discovery of the Occurrence of marine Cretaceous strata on Long Island. By ARTHUR HOLLICK, New Brighton, N. Y. The marine marl beds of the Cretaceous in New Jersey are traced on the north shore of Long Island, and thence perhaps they continue northeasterly as far as Marshfield, Mass., having a course essentially parallel with the general margin of the continent in that region.

Geological Canals between the Atlantic and Pacific oceans. J. W. SPENCER, Washington, D. C. In crossing the isthmus of Tehuantepec, the first 100 miles south from the gulf of Campeche are found to be a plain which rises slightly toward the interior. Then come 25 miles of mountain land, followed by 25 miles more of plain land to the Pacific ocean. The mountain belt is interrupted by two main depressions, through one of which Captain Eads proposed to build a ship railway. The speaker thought that this country has been and is being slowly raised from a marine submergence which reached through these depressions, forming gravel beds there similar to those of valleys in the northern drift-bearing part of the United States. The surface fishes of the gulf of Mexico are the same or nearly allied with those of the Pacific in the gulf of Tehuantepec: but the deep sea forms differ on the opposite sides of the isthmus.

Geological Notes on the Isles of Shoals. H. C. HOVEY, Newburyport, Mass. Five of these islands belong to Maine and four to New Hampshire. Appledore island contains about 350 acres, and the others are smaller. There are proofs that Star, Malaga and Haley islands, at least, were at one time rapidly elevated. Neptune's Punchbowls, so-called, were washed out by the tide daily, but are now eight feet above the tides. The rocks are granite, gneiss and mica schist, with frequent trap dikes. In many places the dikes, being more readily decomposed than the granite through which they extend, have been washed away by the

waves, leaving very narrow and long channels, sometimes 30 to 40 feet deep, through which during storms the sea rushes with great fury.

Subdivision of the Upper Silurian in northeast Iowa. ANDREW G. WILSON, Hopkinton, Iowa. After a brief review of the literature of the subject, this paper gives characteristics for distinguishing the five following subdivisions, in descending order: (5) the building stone beds; (4) the upper coralline beds; (3) the Pentamerus beds; (2) the lower coralline beds; (1) beds of passage from the Lower Silurian.

Supplementary notes on the Metamorphic Series of the Shasta region of California. J. PERRIN SMITH, Palo Alto, Cal. This paper gave the results of work on the Triassic fossils of the Mt. Shasta region, beyond that which is reported in the Sept.-Oct., 1894, number of the Journal of Geology. Fully a hundred species of these fossils are now known and each species is profusely represented by specimens. Ammonites are especially well represented, and the principal part of the paper related to them. In only two other localities of the world are marine Triassic faunas known, namely, in the Tyrolese Alps and in the Himalayas. In California the Karnic division of the Upper Triassic is especially prolific. There are two distinct faunas represented, which are usually 100 feet apart vertically, but they are also found in some places intermingled, either by means of a survival or of a migration.

The manner in which the ontogeny and phylogeny of the ammonites are wound up together was very interestingly shown. By breaking off the chambers and outer coils of the shell, successively, the development of the individual can be traced from the time when the first nucleus of the shell was formed. In applying this process, it was found that the genus under investigation had, in middle life, the characters of a different genus and in earlier life the characters of a still different genus. It is thus possible to arrange a number of genera in phylogenetic order. Trachyceras and Sirenites, for example, while diverse from each other, both run back to a Protrachyceras stage, and this to a Balatonetes stage, and this to a Tirolites form, which appears to be the primitive form for all the others mentioned.

Recent Elevation of New England. J. W. SPENCER, Washington, D. C. The gravel and sand terraces of the river valleys of New England are regarded as not formed by descending rivers, but are so nearly horizontal that they seem referable to bodies of standing water. The platforms or flats do not merge from one step to the next and therefore are not attributed in this paper to formerly higher stages of the rivers, which has been their usual explanation. Instead the successive terraces descend abruptly, like a stairway. Thus a small meadow, near the level of the stream, widens out in passing down the valley to a broad and extensive plain, through which the river channel gradually becomes deeper until the plain abruptly ends by a sudden descent to a lower flat, along the sides of which fragments of the upper plains continue as lateral terraces. In a connected and nearly level series as meadows, plains and narrow terraces, the same flats may continue even

several miles, beyond which they are sometimes represented by delta remnants farther down the valley from which the terrace remains have been removed by erosion. The terrace gravel and sand often extend across the country from one valley to another.

Subject to certain corrections, the succession of terraces and flats marks the repeated lowering of the base planes of erosion, or, in other words, an intermittent elevation of the land, which has been raised approximately as much as the sum of the vertical intervals between the terrace planes. These are commonly situated close together, with only a few feet or tens of feet of elevation between them: but in many localities several of the steps are so combined that the great terraces may be from 50 to 250 feet above the rivers. In the course of a few miles scores of terraces may be ascended or descended and counted with certainty. At any one locality there are seldom more than four or five lateral terraces distinguishable; but these are not identical with the four or five observed several miles up or down the valley wherever the slope of the stream is considerable.

Distinct terrace steps occur up to an elevation of 2,700 feet at the base of Mt. Washington; and similar gravel and sand continue much higher, but without the preservation of the terrace structure upon the steep mountain slopes. Such relationship of gravel terraces has been observed under so many conditions and over so wide extent of territory that it appears to be the prevailing condition, and not the exception. It is nearly everywhere well preserved within the region of the drift, which has been the source of supply for the gravel and sand.

If these deposits, lying as terraces in the valleys and here and there expanding into plains even two or three miles or more in width, were observed only on the northern and western sides of the high lands, they might appear to favor the theory of their formation in glacial lakes. But they also occur on the southern and eastern sides of so many mountain masses as to preclude the idea of their accumulation in glacial lakes. Moreover, the author has observed the same structure within a few degrees of the equator, occurring there at both low and high altitudes. He concludes that the mountainous part of New England has been recently uplifted at least 2,700 feet. As the valleys had been re-excavated out of till, he thinks that the glacial submergence of the region equaled this elevation. The magnitude of the movements in the coastal regions appears to have been less, but this question is still one for future investigations.

Profs. G. F. WRIGHT, H. L. FAIRCHILD, and C. H. HITCHCOCK, in the ensuing discussion, distrusted this interpretation of the valley terraces, and cited reasons for doubting any greater uplift than the 300 to 560 feet above the sea which measure the hight of Champlain marine fossils in Maine and in the St. Lawrence and Lake Champlain valleys.

View of the Ice Age as two Epochs, the Glacial and Champlain. WARREN UPHAM, Cleveland, Ohio. The Glacial period or Ice age, is found divisible in two parts or epochs, the first or Glacial epoch being marked by high elevation of the drift-bearing areas and their envelop-

ment by vast ice-sheets, and the second or Champlain epoch being distinguished by the subsidence of these areas and the departure of the ice, with abundant deposition of both glacial and modified drift. Epeirogenic movements, first of great uplift and later of depression, are thus regarded as the basis of the two chief time divisions of the Ice age. Each of these epochs is further divided in stages, marked in the Glacial epoch by fluctuations of the predominant ice accumulation and in the Champlain epoch by successively diminishing limits of the waning ice-sheet.

Prof. HITCKCOCK, in discussion, said that his view of the Champlain time is that of a cold rather than a mild epoch, judging from the boreal character of the fossils. He congratulated the glacialists on the growing harmony of their views and the diminishing size of the differences which separate them.

Glacial Phenomena between Lake Champlain and Lake George and the Hudson. G. F. WRIGHT, Oberlin, Ohio. This paper gave a detailed description of the stratified gravel, sand and clay, and of the till (with one conspicuous drumlin), in the valleys crossing the water divides south of the two lakes named. Lake George, 225 feet above lake Champlain and 325 feet above the sea, is dammed by deposits of glacial and modified drift at both ends, and is shallowest at the middle of its length, where the Hundred Islands lie. This confirms the conclusion of Mr. S. Prentiss Baldwin, based on his field studies of the district three years ago, that the basin of lake George was drained in preglacial times by two streams, one running northerly and the other southerly. The valley of the northwardly flowing stream, now filled with drift, lies west of the present outlet and is traced to its junction with lake Champlain about halfway between Ticonderoga and Crown Point.

Delta gravels at Glens Falls, Sandy Hill and Schenectady have an elevation of 300 feet, or more, above the sea; but the stratified clays and sand of the Hudson valley eastward and southward, and of the divide between lake Champlain and the Hudson, reach only to 180 feet above tide. The watershed in the valley south of lake George is estimated to be only 30 or 40 feet above that lake; and the canal from the Hudson river to lake Champlain has a summit level of twelve miles only about 150 feet above the sea. The glacial striæ all bear southwestward athwart the prevailing course in Vermont and the east edge of New York, the difference in direction being probably attributable to local southwesterly deflection during the departure of the ice-sheet.

Whirlpool of Niagara. G. W. HOLLEY, Ithaca, N. Y. Attention was directed to the parallelism of the river below the falls with the joints in the Niagara limestone, and the author rejected the theory that a drift-filled preglacial channel extends from the Whirlpool to St. David's.

Prof. SPENCER, in discussion, said that he had made excavations upon the soft northwestern side of the Whirlpool basin, where the buried channel has been supposed to begin, and found rock there up to the hight of 190 feet.

Distribution of Sharks in the Cretaceous. C. R. EASTMAN, Cambridge, Mass. (Read by title.)

Terminology proposed for Description of Pelecypoda. ALPHEUS HYATT, Cambridge, Mass. This paper states that the so-called hinge of bivalves is a general term applicable to the functional part, which as a rule is more extensive than the primitive morphic hinge. For the last the name *cardo* is proposed. This occurs in the young of all forms, as a rule, in some stage; and it is persistent throughout life in some forms, as the Arcidæ, most of the Aviculidæ, the Ostreidæ, and the Pectenidæ. The *cardo* is coextensive with the functional hinge in these families and some others: but in all the more specialized shells of Pelecypods it is confined in the later stages of growth to the central (amphidetic) or posterior (opisthodetic) part of the functional hinge area. The mode of growth of the anterior dorsal part of the shell shoves the anterior arm of the cardo toward the beaks and finally carries this nearly to a line between them, or even posterior to them in the opisthodetic forms. This area may assume either a crescentic or lunate shape, or be heart-shaped, spear-shaped,or linear. The boundaries are traced by the bands of growth that terminate on the borders of this space: and it is, as a rule, completely filled by the morphic ligament. This last is often longer than the functional ligament, and the term is applied here to the whole of the primitively continuous periostracum of the cardo. These are the usual senses in which the terms hinge and ligament have been used. Dall has proposed "resilium" for the differentiated internal parts of the ligament, but has used that term itself for the functional part only of that organ, which is often smaller than the periostracum. The hinge consists then of the *cardo*, which includes cardinal line and area, and also the internal hinge plate and teeth parts developed during the evolution of the Pelecypoda, and for these latter the name *articulus* is proposed. The cardo is the fixed point of comparison. This is dorsal in most Pelecypoda. but may shift to all positions between this and the anterior end of the body, as it does in Ostreidæ, Aviculidæ, Pectenidæ, and Trigonia.

It is proposed that, in descriptions of the exterior of bivalves, paleontologists and conchologists should systematically describe first the *cardo*, next the *articulus*, both as parts of the hinge, and then take up the other areas in succession, beginning at either end of the cardo according to the form, preferably perhaps at the anterior end. The parts anterior to the beaks are in the *anterior region*: the central or *umbonal region* comprises the median and usually more elevated parts: and the *posterior region* lies behind the beaks in elongated shells, but in those with an anterior cardo these regions appear to revolve with the bands of growth, becoming in the Aviculidæ, Pectenidæ and Ostreidæ quite distinct with relation to the beaks. These last and the wings are in the anterior region in these animals, and it becomes necessary to accept different boundaries for the regions. The umbonal elevation is no longer transverse but runs antero-posteriorly, and the posterior region occupies the opposite pole to the cardo, so that it is questionable whether it is

necessary to distinguish a median region running transversely. The terms *ventral* and *dorsal regions* can be more accurately limited than in the specialized forms with dorsal hinges. These lie on either side of a line drawn from the beaks, following the curvature of the growth to the points above the terminations of the gills; and this line is very often marked, as in other Pelecypods, by a ridge or elevation on the valve. The wings, therefore, are not anterior and posterior, as usually described, but are strictly ventral and dorsal wings.

The term *area* is used in all subdivisions of *regions*, and these are often well marked by angles or sinuosities in the bands of growth on the exteriors and margins of the valves. In the Pholadidæ the areas are easily distinguishable; but in many shells two or more areas may run together and are not distinct,—a fact of the greatest importance in describing some shells, since the areas and their blending accurately correspond to differences in the arrangements and proportions of the parts of the internal anatomy.

For the space from the anterior end of the cardo to the depression made by the foot, the name *oral area* is proposed. The depressions, when they occur, are the *pedal sinuses* on the margins and *pedal depressions* on the exterior; and the succeeding elevation becomes the *elevation of the pedal area*. This name is open to the objection that there is no foot in Ostreidæ, and possibly it might be wise to substitute the term *corporeal area*.

Beyond this area posteriorly comes the *branchial area*, marked off by *depressions* in the surfaces and *sinuses* on the margins. This area usually corresponds with the umbonal region in all the Pelecypoda, and as a rule the axis of greatest growth of the valves lies in this area on account of the hypertrophy of the gills, the feeding and breathing organs of these animals. The depressions can be described as the *branchio-pedal depressions*, and the sinuses as the *branchio-pedal sinuses*. The branchial area proper is the space between this and the area occupied by the siphons or siphonal openings.

The *siphonal area* is sometimes quite distinctly marked off from the branchial, and has often, as in the Mactridæ, a sharp siphonal crest. It would be advisable to restrict the use of some terms, like crest, costæ, elevation, depression, if this terminology finds favor with anyone, to radiating structural modifications of the surface, and the terms ridge and striæ, like the lines and bands of growth, to markings parallel with the latter. The bands of growth usually make an angle in crossing the siphonal area, and sometimes another as they bend dorsad to the posterior boundary of the cardo. These are the ventral and dorsal angles of the siphonal area: and the crest, where it exists, is always made by the hypertrophy of the ventral angles. It is often of advantage to distinguish two parts in the siphonal area, the *incurrent* or *inhalent* part ventrad of the siphonal angles or crest, and the *excurrent* or *cloacal* part dorsad of this structure.

The *intestinal area* occupies the space between the dorsal angle of the siphonal area and the posterior termination of the cardo.

It will be seen that the term area can be used equally well whether the shell is equivalvular or inequivalvular. When shells of the first kind are under consideration it is not necessary to speak of the right side of an area; but in the latter of course it becomes important to describe both valves minutely, and then the terms right and left areas can be used and their different relations accurately noted.

In applying these terms to shells with anterior hinges and having wings some modifications are necessary. In a Pecten or Avicula, for instance, the oral area is the ventral wing, and it would be perhaps better to continue to use the term *wing*. The pedal sinus is the *byssal notch*, and there is no reason why this term should not also be continued in use, if it is understood that the areas are homologous and these terms synonymous. The branchial area in these shells is distinguishable from the siphonal in a number of forms, as has been pointed out to the writer by Dr. Jackson.

A good example of the results likely to follow from the application of this or any natural system is found in my cursory study of Malleus. Taking up this shell simply to see whether this terminology would apply, I discovered that the so-called wings are not true wings. The true wings of the oral area are arrested in growth at the end of the neanic (adolescent) stage. In the first of the ephebic (adult) substages the ventral margins of the pedal area in both valves become hypertrophic and grow out into the long so-called anterior wings. The bands of growth may be followed in any shell, sufficiently well preserved to show the true wings in the young, as they pass around the byssal notch and extend ventrad to build up the great ventral arms that are really spatulate outgrowths of the ventral margins of the pedal area.

The Equatorial Counter Currents. W. M. Davis, Cambridge, Mass. (Read by title.)

Interesting Features in the Surface Geology of the Genesee Region. H. L. Fairchild, Rochester, N. Y. This was a lecture illustrated with lantern slides, chiefly relating to the Pinnacle hills in the southeast edge of the city of Rochester, which were described and their mode of formation discussed by this author in the last July number of the Am. Geologist (vol. xvi, pp. 39-51, with map).

Japan. Gardner G. Hubbard, Washington, D. C. (Read by title.)

Great Falls of the Mohawk at Cohoes, N. Y. W. H. C. Pynchon, Hartford, Conn. This paper was illustrated by lantern views. The Cohoes falls have been worn back about seven-eighths of a mile since the end of the Ice age, in Hudson River slates which dip with a slight inclination down stream. Clear indications of a drift-filled preglacial channel are found starting from the Mohawk river about two miles above the falls, passing eastward on the north side of the river and opening out with a broad mouth into the Hudson valley at Waterford.

Section E held a joint session with Section H (Anthropology) on Tuesday afternoon, in which the following paper was presented:

Account of the Discovery of a Chipped Chert Implement in undisturbed Glacial Gravel near Steubenville, Ohio. G. F. WRIGHT, Oberlin, Ohio. This new evidence of Glacial man consisted of a chert implement 1¾ inches long and three-fourths of an inch wide, which was found by Mr. Sam Huston, of Steubenville, Ohio, in a terrace of glacial gravel and sand of the Ohio river valley at Brilliant, in southeastern Ohio, about eight miles below Steubenville. Mr. Huston is a graduate of the scientific department of Washington and Jefferson College, and for twenty-five years has been the county surveyor of Jefferson county, Ohio, being thus perfectly conversant with all the natural features of the region, and especially with the gravel deposits which are extensively used in road-making. He has made paleontological collections for Profs. Cope and Scudder, and so is well known to scientific men.

The implement was discovered by Mr. Huston projecting from the freshly exposed face of an excavation in the terrace gravel about eight feet below the surface and about sixty feet above the Ohio river, and was taken out with his own hands. The gravel was fine and the bedding and cross-bedding above and below were perfectly distinct and undisturbed, showing that the implement is as old as the deposition of the gravel.

Prof. Wright has visited the place with Mr. Huston and says that no one will question that this terrace gravel is of approximately the same age as the gravels at Trenton, N. J., and in the valley of the Somme in France, where similar discoveries have been made. These terrace deposits belong to the Champlain epoch of Dana and were formed near the close of the Glacial period. There is nothing strange, Prof. Wright said, in finding such evidence of men contemporary with the Ice age, for it is abundant in France and southern England; while Dr. Abbott's numerous discoveries at Trenton, N. J., are of the same age. It is especially significant, however, at the present time, because of recent attempts to challenge all the past reported discoveries in this country. It has thus great cumulative force. This is now the third locality in Ohio where similar discoveries of the implements of Glacial men have been made and well attested by competent observers; the other two being at Madisonville by Dr. C. L. Metz, and Newcomerstown by W. C. Mills. Such implements, and artificially chipped fragments from their manufacture, have been also found by Miss Franc E. Babbitt in the glacial gravel of the Mississippi river at Little Falls, Minn., and by Mr. J. B. Tyrrell of the Canadian Geological Survey in a beach deposit of the glacial lake Agassiz in Manitoba. Thus more and more clearly it becomes evident that the study of the Glacial period is an essential preliminary to the study of human history.

In the ensuing discussion Prof. F. W. PUTNAM said that the patina on this implement certainly indicates great age and that its type, though in use up to later times, is a most ancient type which has been kept in use because it was permanently adapted to the wants of savage men.

Mr. F. L. CUSHING said that the implement is a knife of the oldest pattern and that not only is it beyond question a finished implement,

but it had been repeatedly re-sharpened, and that not by the more modern methods of pressure with a bone, but by direct blows upon the edge, indicating its great antiquity.

Prof. J. W. SPENCER remarked that this gravel terrace is somewhat older than the stratified drift of the Connecticut valley.

Prof. E. D. COPE noted a close similarity of this implement with stone implements found by him in Pleistocene beds in Oregon, and regarded them as most allied to Mousterian types.

Dr. R. G. HALIBURTON suggested that implements might be deeply buried in gravel through the modern washing away and redeposition of the beds: but, in reply to this, Prof. WRIGHT stated that the highest modern floods of the Ohio lack some thirty feet vertically of reaching the level of this terrace.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Phylogeny of an Acquired Characteristic. By ALPHEUS HYATT. (Ex. Proc. Am. Phil. Soc., vol. XXXII, no. 143, pp. 349-647, pls. 1-14, Aug., 1894.) Anything bearing upon the inheritance and phylogeny of an acquired character is especially interesting in these days of active discussion upon the same and kindred topics, and the present paper is very opportune, since it approaches the subject from a side which is quite impossible in ordinary biology. Few besides professor Hyatt can bring to bear for this purpose such an extensive knowledge of the development and phylogeny of recent and fossil forms of any single class of animals. Moreover, the cephalopods offer a wealth of material for the study of ontogeny and phylogeny; their geological history has been long, and a vast number of species has been described. The division Tetrabranchiata, now ranked as a subclass by the author, has furnished the richest material and has been made the subject of greatest study. One large order, the Nautiloidea, began and culminated in Paleozoic time, while the other, the Ammonoidea, began later in the Paleozoic, but culminated and went out in the Mesozoic. It is seen, therefore, that an opportunity is afforded for making parallel correlations in two related orders, having much the same general type of form, through widely different geological ages.

In the preliminary discussions professor Hyatt emphasizes the value of the shell as an expression of the external form of the animal as giving what the adult internal soft parts alone cannot, viz., an accurate history of the changes and events in the organism from its embryonic stages through youth, maturity and old age to the time of its death. In brachiopods, gastropods, pelecypods and cephalopods the embryonic shell is at the apex, around which growth takes place, and, in well-preserved specimens, all the subsequent stages may be traced. A farther advantage in the cephalopods exists in the internal structures, principally the siphuncle and septa. The former exhibits changes of structure and position during the life of the animal, and the latter with their

sutures vary with age, thus making, with the external shell, three records of mutations. The value of such material for phylogenetic study can be best appreciated in comparison with that obtainable in other groups, such as the vertebrates. The author says upon this point: "How unreasonable it would seem to a student of fossil Mammalia, if he were requested to do what it would be appropriate to require from a student of the fossil Cephalopoda, viz., to describe from the investigation of a single perfect fossil skeleton of an adult, not only the characteristics of the skeleton at the stage of growth at which the animal died, but the developmental stages of this same skeleton, and in case it were the remains of an old, outgrown animal, also, the retrograde metamorphoses through which it had passed during its last stages of decline. It might require a life time to make out the stages of a single species of mammal satisfactorily from the isolated specimens which would be found and the attempt would be hopeless for all the youngest stages of growth, while the bones were still cartilaginous.

"This kind of evidence, however, is readily obtainable among fossil Cephalopods with relation to the shell and other hard parts as among living animals, and it can be obtained in good collections everywhere, whether 'in situ' or in museums. Thus it is possible to study the relations of these fossil forms very minutely and with the certainty of possessing a clue to their true relations, which is rarely obtainable even among existing animals. For among these we have only the embryos and young of contemporaneous forms and necessarily lose all relations of succession in time, unless the investigation embraces a prolonged series of experiments or is more or less historical, and even then the facts cannot have a very wide chronological range."

The classification adopted is as follows: Class Cephalopoda, with two subclasses; I. Tetrabranchiata, containing the orders Nautiloidea and Ammonoidea: II. Dibranchiata, containing the orders Belemnoidea and Sepiodea.

The four orders show a common origin through their development, their morphology and their having a similar embryonic shell, the protoconch. The primitive forms, the nautiloids, gave origin to the dibranchs through the gradual modification of the external shell into an internal organ. Transitional forms are met with, such as *Aulacoceras* of the Trias. The development of *Loligo*, as shown by Lankester, indicates an enclosure and suppression of the external shell. Such predictions are now substantiated by a morphological study covering the geological history of the group.

The author shows that, from a number of old nautiloid stocks, there arose successively series of straight, arcuate, gyroceran and involute shells, and that the old idea of a gradual progression of similar forms through the order as a whole, the arcuate and gyroceran in later periods and the involute last, can only be applied to single branches of the phylum. From a general view of the order, Barrande showed that there were straight, arcuate and coiled forms appearing all through Paleozoic time and considered that this progression of form did not indicate phy-

logeny and could not be used to illustrate the evolution of the class. These objections are now met, as indicated above, by studying development within the families and genera.

It may be accepted as a law that animals near their points of origin in early geologic time evince marked tendencies toward rapid evolution. They found the earth comparatively unoccupied or occupied by inferior animals, and through such conditions favorable to numerical increase were forced to migrate in every direction and thus to come in contact with and adjust themselves to many different physical surroundings. Similar cases of quick evolution of new series and many species occur in later times as well as to-day, whenever a stock finds an unoccupied field. In this connection the author instances the well-known *Planorbis* development in the Steinheim basin and the evolution of the extensive family of the *Arietidæ*, consisting of eleven distinct series, arising, culminating and ending within the limits of the Lower Lias. Another marked case illustrating the same point, which might be mentioned, is the extreme differentiation of the genus *Gammarus*, an amphipod from lake Baikal, which probably since glacial times has developed from a single form one hundred and fifteen species, many of them highly ornamented and specialized, and together constituting more species than are known elsewhere, although the genus is world wide.

Before taking up a detailed description and discussion of the various genera and species of cephalopods which furnish professor Hyatt with the main points of his argument, he introduces a chapter on the principles of bioplastology, or the characteristics of development and decline in the life of an individual. This has already been published in part elsewhere and reviewed in the GEOLOGIST. The terms adopted will be found useful in accurately indicating any stage of ontogeny or any kind of development and in correlating them with periods of phylogeny.

A complete application of the ontogenetic stages is then made to the shell covered Cephalopoda, together with definitions of descriptive terms for various features and structures. Of these the *impressed zone* is the one to which special attention is called, as it forms the basis for the investigation of the inheritance of an acquired characteristic. The impressed zone is primarily the area on the dorsum which is flattened, convex or indented by the contact of the growing whorl with the venter of the already formed whorl of the next inner volution.

It is shown that the impressed zone is invariably consequent upon close coiling, never appearing in ancestral forms in the early stages unless through this agency. It is, therefore, a mechanical and necessary result of the pressure of one whorl upon another and must be accepted as strictly an acquired character. The influence of tachygenesis, or the progressive earlier inheritance of characters, results in the development of the impressed zone (then called the dorsal furrow) in very young shells belonging to later genera, before the whorls come in contact with each other. In other words, the genera geologically later than the ancestral forms of the different groups show an impressed zone during growth stages before the appearance of the mechanical conditions which

originally produced it. From this it would also be expected that the impressed zone would persist in old age forms in which the outer whorl becomes free from the coil. This is often found to be the case, as in *Eurystomites kelloggi* from the Quebec group. It is less noticeable in the ammonoids, for many old age forms return to the normal cylindrical form of the tube soon after the whorls become free.

The Weissmannian school deny that acquired characters are inherited, but the results of the studies here briefly described show the contrary. "It is practicable to isolate inherited characters from new variations which have not become fixed in any phylum. It is also practicable to point out characters which are transient in various ways appearing in individuals but not in varieties, in species but not in genera, and so on. When one has by this system of exclusion arrived at the end of the list he finds that there is no class of characteristics which may be described as non-inheritable. The new variations of any one horizon which can be isolated from the inherited ones are not distinguishable in any way from others which occurred previously. Later in time these new variations in their turn become incorporated with the younger stages of descendants. The transient characters of the zoön also do not differ in any way from others that are inherited in allied species, genera, etc." "All characteristics, even those observable in some groups only in old age, are found in the adults of other groups and finally in the young of the descendents of these, according to the law of tachygenesis. Everything is inherited or is inheritable, so far as can be judged by the behavior of the characteristics." In conclusion: "These cumulative results favor the theory of tachygenesis [earlier inheritance] and diplogenesis [acquired and hereditary] and are opposed to the Weissmannian hypothesis of the subdivision of the body into two essentially distinct kinds of plasm, the germplasm, which receives and transmits acquired characteristics, and the somataplasm, which, while it is capable of acquiring modifications, either does not or cannot transmit them to descendants."

How much more satisfactory and conclusive are the results obtained through the historical study of a character manifestly acquired by mechanical necessity and running through long geological ages than to attempt similar results by cutting off the tails of mice and expecting to produce a breed of anurous *Mus*! So far as known to the reviewer, professor Hyatt has given the most complete scientific demonstration of the inheritance and phylogeny of an acquired character. C. E. B.

Structure and Appendages of Trinucleus. By C. E. BEECHER. (Am. Jour. Science, vol. XLIX, p. 307, pl. iii, 1895.) From the study of a series of specimens of *Trinucleus concentricus* Eaton, found associated with *Triarthrus becki* Green, in the Utica slate near Rome, N. Y., the author shows that, in young conditions, distinct ocular ridges terminating in an ocular node are present, though in this species of the genus they become atrophied at maturity. This structure brings the genus into relationship with *Harpes*, whose eyes are ocelli and situated upon the fixed cheeks, very distinct from the structure of the visual organ in

the schizochroal (*Phacops*) and holochroal (*Asaphus*) groups. The presence of appendages upon the segments of the thorax and pygidium is established, though those of the former are much obscured by the thick fringe of the exopodites. A similar fringe accompanies the exopodites of the pygidium, while the endopodites are broad and phyllopodiform, if less strikingly so than in *Triarthrus*. J. M. C.

Report on the Coosa Coal Field, with sections. By A. M. Gibson. (Geological Survey of Alabama, 143 pp., one plate. Montgomery, 1895.) Alabama in 1893 ranked fifth in coal production in the United States, with a total of over five million tons. This tonnage comes from four different fields having the following areas as given by state geologist E. A. Smith.

Warrior field:	
Plateau region	2,275 sq. mi.
Basin region	4,955 sq. mi.
Lookout mountain	580 sq. mi.
Cahaba field	435 sq. mi.
Coosa field	415 sq. mi.

The Geological Survey of Alabama has devoted a good share of its resources to an investigation of these coal fields. T. H. Aldrich in 1875 gave a history of early mining in Alabama, Mr. Squire has reported on the Cahaba field, and Mr. McCalley upon the Warrior field as a whole (1886) and upon the plateau region alone (1892), and Gibson has published a report on the Blount county deposits.

The present report by Mr. Gibson deals with the Coosa field alone. This is the smallest of the Alabama fields and contains, according to his surveys, some 345 square miles of productive area. It stretches in a long narrow belt having an average width of five to six and a length of some sixty miles. It lies mainly in St. Clair and Shelby counties with a slight prolongation into Cahun. The field is a narrow synclinal valley bordered by high marginal mountain rims and is in addition, as a result of transverse faults, traversed by numerous mountain ridges which give it a very rugged topography. The Coosa field is divided in eight basins: the Ragland, Fairview, Coal City, Black Ankle, Kelley's Creek, Howard, Peavine Creek, and Yellow Leaf; each of which is considered in detail. The principal development so far has taken place in the Ragland and Coal City areas. It was from the former that the Confederate ordnance works at Selma drew their supplies. The beds are not thick, but run regularly and seem to be of considerable uniformity. The coals are of good quality, free burning, low in sulphur and well adapted to steam and grate use. The Coal City and Ragland seams furnish an especially good quality of coke. At the latter place the coke is made from the fine coal after being washed.

In the report a large number of workable beds are noted and, while the present peculiar economic conditions confine the active work of mining to two points only, in the future an important development may be confidently expected. H. F. B.

The Origin of the Arkansas Novaculites. By L. S. GRISWOLD. (Proc. Boston Soc. Nat. Hist., vol. 26, pp. 414-421. Author's edition, Feb. 9, 1895.) In the Quarterly Journal of the Geological Society of London, Aug., 1894, Mr. Frank Rutley brought forward arguments to show that the novaculites of Arkansas were siliceous replacements of dolomite or of dolomitic limestone beds. (His paper, "On the Origin of certain Novaculites and Quartzites," was reviewed in the AMERICAN GEOLOGIST, vol. 14, p. 253, Oct., 1894.) This explanation of the origin of the novaculites is at variance with that adopted by Mr. Griswold, who had made a careful examination of and a report on these peculiar rocks (Annual Report of the Geological Survey of Arkansas for 1893, vol. 3). In the present paper Mr. Griswold defends his theory of the formation of these novaculites, maintaining that they are simple, fine grained, siliceous sediments mechanically deposited, i. e., that they are sandstones of very fine grain. He does not regard the presence of irregularly rhomb-shaped cavities, once probably filled with some carbonate (dolomite), as evidence that the whole rock has been derived from a dolomite by siliceous replacement, and he argues that the novaculite is not composed of chalcedonic silica as thought by Mr. Rutley. U. S. G.

Ueber palæozoische Faunen aus Asia und Nordafrika. By F. FRECH. (Neues Jahrb. für Mineral., etc. Jahrg. 1895, Bd. 2, Heft. 1, pp. 47-67.) This paper contains interesting paleontologic news from various remote corners of the world, the facts having been brought together, as the author states, in pursuance of his plan for the completion of F. Roemer's "Lethæa Palæozoica." From the Lunschau, a mountain near Nanking, China, are described fossils from the lower Ordovician, *Asaphus*, *Endoceras duplex*, *Raphistoma sinense*, sp. nov., etc. From the province of Schantung in north China and from the Yang-tse in middle China is a well defined Carboniferous limestone fauna with a variety of characteristic species. The province of Kiang-su also affords a few Permian species, and the upper faunas of this formation, with *Gastrioceras* and *Paraceltites*, have been found near Ning-kwo-hsien, in the province of Nganhwei. Persia, in the vicinity of lake Ooromiah, furnishes Carboniferous species, *Productus*, *Spirifer striatus*, *Syringothyris*, etc., and from Schaku Tschalkhune certain species of probable Permian age. An upper Devonian brachiopod fauna is reported in this vicinity, with *Spirifer disjunctus*, *S. anossofi*, *Atrypa concentrica*, *Rhynchonella pugnus*, *Orthis striatula*, *Orthothetes umbraculum*, *Phacops latifrons*, etc.

Devonian brachiopods were described by Beyrich in 1852 from the Hammada, near Murzuk in Tripoli. These, three in number, are reviewed by the author and two of them are shown to represent the genus *Liorhynchus* and the third a well known Chemung species, *Spirifer mesacostalis*. J. M. C.

Folds and Faults in Pennsylvania Anthracite Beds. By BENJAMIN SMITH LYMAN, (Trans. Amer. Inst. Min. Eng., Atlanta meeting, 1895, pp. 1-43.) The author gives thirty-three plates containing 177 highly interesting and instructive sections, prepared from cross-section sheets

of the Pennsylvania Survey. All are in a N. W.-S. E. direction and are viewed from the south. H. D. Rogers held it to be a general law for eastern Pennsylvania that northwesterly dips are steeper than the southeasterly ones. Mr. Lyman concludes, from the study of these sections, that "steep northerly dips in the Pennsylvania anthracite region are much less prevalent than was formerly supposed; that nearly half of the basins and saddles are about symmetrical; * * * that the subordinate folds throughout the region are confined to subordinate groups of beds of inferior firmness, and are not parallel to the main folds, but probably at uniform profile-distances from the main axes, so as to descend the flank of a sinking anticlinal. Further, that the faults are almost invariably longitudinal or reversed faults, occasioned by the overstraining of subordinate folds." J. M. C.

Directions for Collecting and Preparing Fossils. By CHARLES SCHUCHERT. (Bull. U. S. Nat. Mus., no. 39, part K, pp. 1-31, 1895.) The paleobiologist of to-day is making such exactions of the collector and has raised to such a fine art the preparation of fossils that concise suggestions such as Mr. Schuchert has here brought together from his own and others' experience will be found of general usefulness. The best collector is the one who collects as much by faith as by sight, and the most skillful preparateur he who adapts his methods to the nature of his subject. J. M. C.

On a New Trilobite from Arkansas Lower Coal Measures. By A. W. VOGDES. (Proc. California Acad. Sci., ser. 2. vol. IV, p. 589, 1895.) Describes *Griffithides ornata* as a new species, from Conway county, Ark. Its similarity to *G. scitula*, Meek & Worthen and *G. cliftonensis*, Shumard, is pointed out and the suggestion made that all may prove referable to Shumard's species. J. M. C.

A Supplement to the Bibliography of the Palæozoic Crustacea. By A. W. VOGDES. (Proc. California Acad. of Sci., ser. 2, vol. V, pp. 55-76, 1895.) Gives 141 titles of papers published since 1893 or omitted from the author's larger work of that date. It is an important addition to that very useful compilation. J. M. C.

Tables for the Determination of Common Minerals, chiefly by their physical properties, with confirmatory chemical tests. By W. O. CROSBY, Ass't Prof. of structural and economic geology in the Massachusetts Institute of Technology. (106 pp.; third edition, rewritten and enlarged; Boston, 1895, published by the author. Price, $1.25.) In these tables the author has endeavored to do away with, as far as is possible, elaborate chemical tests in the determination of minerals. The more obvious physical properties are used as the chief means of determination, the general classification being based entirely on physical characters. In this classification the minerals are divided into two great classes, metallic and non-metallic, according to their luster. Under each of these classes are five subclasses, distinguished according to the color in the metallic and according to the color of the streak in the non-metallic.

The species of each subclass are further divided into four groups according to their hardness, being classed as very soft, soft, hard and very hard. The method of determination or the "key" is analogous to that used in analytical botany, and the author aims to show that the common minerals can be determined with the same ease and accuracy as the common plants. Under each species is given a number of physical characters and finally one or more confirmatory chemical tests. Only about two hundred of the more common minerals are included in the tables, but there is a supplementary table that includes one hundred of the less common minerals which are occasionally encountered by the student. As these tables are comparatively simple and as they require but little chemical knowledge and but a small amount of apparatus, it would seem that they are especially well adapted to the general uses of schools, colleges and private students. U. S. G.

A Contribution to the Mineralogy of Wisconsin. By WILLIAM HERBERT HOBBS. (Bull. Univ. of Wis., sci. ser., vol. 1, no. 4, pp. 109-156, pls. 4-8; June, 1895.) This paper is devoted largely to the crystallography of Wisconsin minerals and seems to be the first description of the crystallographic features of the minerals of that state. The specimens measured and figured come from three sources: (1) the pre-Silurian rocks; (2) the cavities of the Galena limestone in southern Wisconsin; (3) the Hamilton cement rock at Milwaukee. A large number of careful measurements were made; this work brought out some interesting results, among which was the determination of several hitherto undescribed forms, as follows: two on quartz, three on calcite, one on cerussite, one on sphalerite and four on azurite. Anglesite has been reported several times from southern Wisconsin, but the specimens examined prove to be selenite.

A few pages are devoted to "diamonds from the drift." The main facts concerning these have been already presented by Dr. Hobbs in the AMERICAN GEOLOGIST (vol. XIV, pp. 31-35, July, 1894). U. S. G.

RECENT PUBLICATIONS.

I. Government and State Reports.

Geol. Surv. of Ala. Report upon the Coosa coal field, with sections, A. M. Gibson. 143 pp., 1895.

U. S. National Museum, pt. 1 of Bull. 39. Directions for collecting rocks and for the preparation of thin sections, G. P. Merrill.

Geol. Surv. of Canada, Ann. Rept. for 1892-'93, vol. 6, 1895. Summary report on the operations of the Geological Survey for the years 1892 and 1893, by the Director, A. R. C. Selwyn: Preliminary report on the geology of a portion of central Ontario, situated in the counties of Victoria, Peterborough and Hastings, F. D. Adams; Preliminary report on geological investigations in southwestern Nova Scotia, L. W. Bailey; Chemical contributions to the geology of Canada from the laboratory of the Survey, G. C. Hoffman; Division of mineral statistics and mines, E. D. Ingall and H. P. H. Brumell.

Bureau of Mines (Ontario), Fourth (1894) Report; Archibald Blue, Director,. General introduction; Gold in Ontario—its associated rocks and minerals (Report on the Rainy Lake gold region), A. P. Coleman: The Hinterland of Ontario; Calcium carbide and acetylene gas; Diamond drill explorations; Nickel and its uses; Mining accidents; Fifth report of the inspector of mines, A. Slaght.

U. S. Nat. Museum, pt. K of Bull. 39. Directions for collecting and preparing fossils, Charles Schuchert.

U. S. Geol. Survey. Mineral products of the United States, D. T. Day. June 8, 1895. [Large table.]

Boletin de la Comision Geologica de México, Num. 1. Fauna fosil de la Sierra de Catorce San Luis Potosi, J. G. Aguilera.

II. Proceedings of Scientific Societies.

Trans. Acad. Sci. of St. Louis, vol. 7, no. 3, Feb. 21, 1895. Note on the glacial drift in St. Louis, H. A. Wheeler; Note on the occurrence of blende in lignite, H. A. Wheeler; Recent additions to the mineralogy of Missouri, H. A. Wheeler.

Proc. Iowa Acad. Sci., for 1894; vol. 2, 1895. Interloëssial till near Sioux City, Iowa, J. E. Todd and H. F. Bain; Preglacial elevation of Iowa, H. F. Bain; Secular decay of granitic rocks, C. R. Keyes; Record of the Grinnell deep boring, A. J. Jones; Lansing lead mines, A. G. Leonard; How old is the Mississippi, F. M. Fultz; Maquoketa shales in Delaware county, Samuel Calvin; Occurrence of Megalomus canadensis, Hall, in Le Claire beds at Port Byron, Illinois, W. H. Norton; Certain minerals of Webster county, Iowa, A. C. Spencer; Cement materials in Iowa, H. H. Lonsdale; Mississippian rocks of central Iowa, H. F. Bain; Topaz crystals from Thomas mountain, Utah, A. J. Jones; Formation of the flint beds of the Burlington limestone, F. M. Fultz; Synopsis of American Paleozoic echinoids, C. R. Keyes; Geological section of the Y. M. C. A. artesian well at Cedar Rapids, Iowa, W. H. Norton; Upper Carboniferous of southwestern Iowa, E. H. Lonsdale; Coincidence of present and preglacial drainage system in extreme southeastern Iowa, F. M. Fultz; Extension of the great ice sheet into Iowa, F. M. Fultz; Glacial markings in southeastern Iowa, F. M. Fultz; Opinions concerning the age of the Sioux quartzite, C. R. Keyes.

Trans. Connecticut Acad. Arts and Sci., vol. 9, pt. 2, 1895. Revision of the families of loop-bearing Brachiopoda, C. E. Beecher; The development of Terebratula obsoleta Dall, C. E. Beecher.

Proc. Lake Superior Mining Institute, 3d Ann. Meeting, March, 1895. The iron ranges of Minnesota, H. V. Winchell; Distribution of phosphorus and system of sampling at the Pewabic mine, Michigan, E. F. Brown; The relation of the vein at the Central mine, Keweenaw point, to the Kearsarge conglomerate, L. L. Hubbard; Open pit mining with special reference to the Mesabi range, F. W. Denton.

III. Papers in Scientific Journals.

Amer. Naturalist, July, 1895. On a supposed case of parallelism in the genus Palæosyops, Charles Earle.

Amer. Naturalist, Aug., 1895. On the presence of fluorine as a test for the fossilization of animal bones, Thomas Wilson.

Science, July 12, 1895. Current notes on physiography (XII), W. M. Davis.

Science, July 26, 1895. Current notes on physiography (XIII), W.M. Davis.

Science, Aug. 2, 1895. A rock fissure, G. K. Gilbert.

Science, Aug. 9, 1895. Saporta and Williamson and their work in paleobotany, L. F. Ward.

Science, Aug. 16, 1895. The history, aims and importance of the American Association for the Advancement of Science, F. W. Putnam; Vertebrate paleontology in the American Museum, H. F. Osborn; The causes of the Gulf stream, Joseph LeConte.

Science, Aug. 23, 1895 .Current notes on physiography (XIV), W. M. Davis.

Science, Aug. 30, 1895. Current notes on physiography (XV), W. M. Davis.

Science, Sept. 6, 1895. Seventh summer meeting of the Geological Society of America, J. F. Kemp.

Kansas University Quarterly, vol. 4, no. 1, July, 1895. Natural gas and coal oil in Kansas, E. H. S. Bailey; Note on the mandible of Ornithostoma, S. W. Williston; The Coffeyville explosion, Erasmus Haworth.

Bull. Amer. Geographical Soc., vol. 27, no. 2, 1895. A journey up the Yukon river, I. C. Russell; The composite origin of topographic forms, A. P. Brigham.

Amer. Jour. Sci., Aug. 1895. The earth a magnetic shell, F. H. Bigelow; Note on the occurrence of leadhillite pseudomorphs at Granby, Mo., W. M. Foote; Distribution and the secular variation of terrestrial magnetism, No. 1, L. A. Bauer; Complimentary rocks and radial dikes, L. V. Pirsson; Mineralogical notes, W. H. Hobbs; Calaverite from Cripple Creek, Colo., W. F. Hillebrand; Thomas Henry Huxley, O. C. Marsh.

Amer. Jour. Sci., Sept., 1895. Distribution and the secular variation of terrestrial magnetism, No. 2, L. A. Bauer; Outlying areas of the Comanche series in Kansas, Oklahoma and New Mexico, R. T. Hill; Stratigraphy of the Kansas Coal Measures, C. R. Keyes; On the so-called Schneebergite, E. S. Eakle and W. Muthman; Native sulphur in Michigan, W. H. Sherzer; On two new meteorites, E. E. Howell.

School of Mines Quarterly, July, 1895. Segregation in ores and mattes, D. H. Browne. Appended note to paper of Mr. Browne, J. F. Kemp.

Jour. of Geology, July-Aug., 1895. Notes on the Glacial deposits of southwestern Alberta, G. M. Dawson; Experimental application of the photo-topographical method of surveying to the Baird glacier, Alaska, O.J. Klotz; The Cambro-Silurian question in Missouri and Arkansas, C. R. Keyes; Notes on an examination of a collection of Inter-glacial wood from Muir glacier, Alaska, F. H. Knowlton; Lake Passaic—an extinct Glacial lake, R. D. Salisbury and H. B. Kümmel; Description of a new species of Petalodus (P. securiger) from the Carboniferous of Illinois, O. P. Hay: Glacial studies in Greenland (VI), T. C. Chamberlin.

Technology Quarterly, vol. 8, no. 1, Apr., 1895. Composition of the sulphur petroleums of Ohio and Canada, C. F. Mabery.

IV. Excerpts and Individual Publications.

A supplement to the bibliography of the Palæozoic Crustacea, A. W. Vogdes. Proc. Cal. Acad. Sci., ser. 2, vol. 5, pp. 53-76, 1895.

The erosive action of ice, G. E. Culver. Trans. Wis. Acad. Sci. etc., vol. 10, pp. 339-366, 1895.

A geological section across the northern part of Illinois, J. A. Udden. Rept. Ill. Board World's Fair Com., pp., 117-151.

The volcanic rock of Alum hill, Boulder county, Colo., C. I. Andrews. Read before the Colo. Sci. Soc., June 3, 1895; 8 pp.

Folds and faults in Pennsylvania anthracite beds, B. S. Lyman. Trans. Amer. Inst. Mining Eng., Atlanta meeting, 43 pp., 34 pls., 1895.

The Onyx marbles: their origin, composition and uses, both ancient and modern, G. P. Merrill. Rept. of U. S. Nat. Museum, 1893, pp. 539-585, pls. 1-18.

Tables for the determination of common minerals chiefly by their physical properties, with confirmatory chemical tests, W. O. Crosby. 3d Ed., rewritten and enlarged, 106 pp.; Boston, Published by the Author, 1895.

On the Organic remains of the Little River group, No. II, G. F. Matthew. Trans. Roy. Soc. Canada, Sec. 4, 1894, pp. 89-111, pl. 1.

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Bull. University of Wis. A contribution to the mineralogy of Wisconsin, W. H. Hobbs. Sci. Ser., vol. 1, no. 4, pp. 109-156, pls. 4-8, June, 1895.

Bull. Museum Comp. Zoöl. Fossil sponges of the flint nodules in the lower Cretaceous of Texas, J. A. Merrill. Vol. 28 (Geol. Ser., vol. 3), no. 1, pp. 1-26, 1 pl., July, 1895.

Bull. Dept. of Geol. Univ. of Calif. Critical periods in the history of the earth, Joseph LeConte. Vol. 1, no. 11, pp. 313-336, Aug., 1895.

CORRESPONDENCE.

THE INTERNATIONAL CONGRESS OF GEOLOGISTS: — A CORRECTION. Without in anywise wishing to call in question the general statements of the article by Dr. Persifor Frazer in No. 4, volume XIV, of the AMERICAN GEOLOGIST, entitled "The Sixth Session of the International Congress of Geologists," still I must ask you to place before your readers the following corrections of the statements which affect me personally in the above mentioned article.

On pages 266-267: The prize awarded to me in Bologna amounted to 2,000 francs, not 1,100. I did not ask Prof. Capellini "shortly afterward" to loan me my manuscript for a while, but this was done first at the beginning of the preparation for the geological map of Switzerland on the scale of 1 to 500,000, one year before the last Congress. I did not keep my manuscript thirteen years, as Dr. Frazer says, but only about a year and a half, and it is already back in Bologna. In the Report of Bologna

my work which won the prize is only a French translation, and it appears with hardly one-sixth of the illustrations. In Switzerland in most of the institutions which give prizes it is customary that the works which compete for prizes remain *the personal property of the authors.* In 1881 no determination whatever concerning the personal ownership had been reached. When Prof. Capellini, on the other hand, was of the opinion that my manuscript should remain in the archives at Bologna, I considered it the wisest and the best course to lay the question before the Congress for decision. I have since then done as it decided and can see no fault in my conduct,—it was correct.

On page 269: Dr. Frazer is not familiar with the use of the German language when he accuses us of having erred a year in the age of Prof. Beyrich. We knew very well that on this day Prof. Beyrich was only seventy-nine years old, but that is called "*the eightieth birthday,*" because the first and most important birthday should be numbered, and we celebrated entirely correctly his eightieth birthday or the beginning of his eightieth year of life.

I will not mention numerous other misunderstandings, because they do not affect me personally.

Zurich, March 15, 1895. PROF. DR. ALBERT HEIM.

PERSONAL AND SCIENTIFIC NEWS.

PROF. J. W. JUDD has been appointed successor of Huxley as dean of the Royal College of Science, South Kensington.

THE PROFESSORSHIP of geology and mineralogy in the University of Toronto is vacant, owing to the resignation of Prof. Chapman. (*Science.*)

DR. G. P. GRIMSLEY, of Columbus, Ohio, has accepted the professorship of geology and natural history in Washburn College, Topeka, Kansas.

MR. RAPHAEL PUMPELLY, ex-state geologist of Michigan, and PROF. HENRY LLOYD SMITH, of Harvard, have gone to the Seine River gold district, Ontario, on professional business. (*Eng. & Mining Journal.*)

DR. HENRY M. AMI, of Ottawa, Canada, assistant paleontologist in the Geological Survey Department, has just returned home from Europe, whither he had gone to seek rest last spring after a trying illness. He returns greatly improved.

MR. MAX KRAHMANN, editor of the "Zeitschrift für praktische Geologie," announces that hereafter that journal will be published in Berlin (Charlottenburg, Schillerstrasse 22), and that in connection with it he will establish a "Bureau for Practical Geology," where maps, books and advice concerning economic geology can be obtained.

SEVERAL DISTINCT EARTHQUAKE SHOCKS were felt in New York, Brooklyn, Philadelphia and vicinity early on the morn-

ing of September 1st. These cities are situated on the "fall line," which is supposed to be the line of a fault of comparatively recent date. Motion along this fault is probably still in progress, as evinced by the above mentioned disturbance and the great Charleston earthquake.

UNION COLLEGE has recently issued an announcement of the courses offered by the department of geology and paleontology for the present college year. This department is under the direction of Prof. Charles S. Prosser. Special attention is called to the excellent facilities for the study of localities in the immediate vicinity of Schenectady, which have become classic in the history of North American geology.

THE NORTHWEST MINERS' ASSOCIATION has been temporarily organized and a call has been made for the first general meeting at Spokane, Washington, October 2d and 3d. At this meeting it is proposed to effect a permanent organization and to elect permanent officers. It is hoped to enlist for this association the hearty support of all who are engaged, in whatever capacity, in mining in the states of Washington, Idaho, Montana and Oregon, and the province of British Columbia.

THE AMERICAN INSTITUTE OF MINING ENGINEERS will hold its sixty-ninth meeting at Atlanta, Ga., beginning October 8th. Several excursions have been arranged, and a special train has been engaged to convey members and guests from Washington to Atlanta and return. Mr. E. W. Parker, of the U. S. Geological Survey, Washington, is in charge of all matters connected with transportation, and Prof. W. H. Emerson, Georgia School of Technology, Atlanta, is the secretary of the local committee.

THE THIRD VOLUME OF THE PROCEEDINGS OF THE LAKE SUPERIOR MINING INSTITUTE has recently appeared. The articles contained are chiefly on matters pertaining to mining rather than geology, such as descriptions of pumping tests in the Lake Superior region and in New Jersey, and of hoisting machinery at Ishpeming. The only geological paper is one by Dr. L. L. Hubbard, the State Geologist, of Michigan, on the "Relation of the Vein at the Central Mine, Keweenaw Point, to the Kearsarge Conglomerate." This paper, which is illustrated by some interesting sections, is of value to the geologist for the clues which it affords as to the relations which subsist between the eastern and the western sandstones of Keweenaw point; and has a particular interest for those engaged in copper mining because it identifies the Kearsarge conglomerate and locates the edge of the basin in which it was deposited. A concise account of the developments on the Vermilion and Mesabi iron ranges, which was prepared for the Minnesota meeting of the Institute by H. V. Winchell, is reproduced in this volume.

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[CRUCIAL POINTS IN THE GEOLOGY OF THE LAKE SUPERIOR REGION. No. 9.]

THE LATEST ERUPTIVES OF THE LAKE SUPERIOR REGION.

By N. H. WINCHELL, Minneapolis, Minn.

Prof. Irving has called attention to the view of Whittlesey and of Foster and Whitney that the Lake Superior basin is a great synclinal, which began early in its history, and has illustrated the depression with fresh facts and a lucid mapping by contours.* Two principal formations are concerned in giving the leading topographic expression of this general truth, viz., the Animikie and the Keweenawan. These strata display their entire thickness in bluffs that face outward from the basin and constitute the rim which discloses in the main the salient steps in the physical history, as well as of the geology of the great synclinorium. The line of breaking which caused these strata to rise thus and present a rampart against the older terranes was very regular on the northern side of the lake from Duluth to Thunder bay, but on the south side of the lake it was broken and even tortuous eastward from the base of Keweenaw point. From the western extremity of the basin eastward to about the middle of the same the tilting of these formations was regular and synchronous, the southern line of the rim running out to the extremity of Keweenaw point, where it turned toward the southeast. The northern line of the rim runs about parallel with the southern, but begins to

*The Copper-bearing rocks of lake Superior, pl. XXVIII.

turn to the southeast and to lose its characteristic dip, in a large measure, eastward from Pigeon point. The line of fracture and of high dip leaves the mainland and passes to Isle Royale and is lost under the lake at the extremity of that island. Prof. Irving has supposed that it continues, under the lake, to Michipicoten island, where it rises to view again, still having a southerly dip. It is to be noticed that on each side of the lake the line of extreme tilting runs under the lake at points nearly opposite each other and near the longitude at which they are both deflected toward the southeast. Eastward and southeastward from Keweenaw peninsula, and backward from its great tilting rampart, lie later sandstones (the "Eastern sandstone"), practically concealing, along the lake shore, the older geology. Analogy suggests the same age for the sandstones that are north of the rampart on the north side of the lake.

But this conclusion does not rest alone on analogy. There are certain physical structures that point strongly in the same direction. The whole topography of the national boundary, along the north side of Minnesota, extends, near the coast, as far as Thunder bay. But this is farther north than the great fracture line which marks the summit of the tilted rampart. This summit is characterized by the heavy gabbro masses and the red granites and felsytes from twenty to thirty miles further south. This hill range (the Mesabi range) leaves the north shore of the lake at Pigeon point, some of its great dikes being somewhat still further north. It rises again in Isle Royale, but for the most part it is under water entirely eastward from that point. The very southernmost part of this line of elevation, i. e., the dikes of the Animikie revolution, appears along the north shore of Isle Royale, where some of its characteristic gabbro dikes rise perpendicularly from the water to the hight of several hundred feet, sometimes without a shred of the Animikie attached. The rocks of the Lucille islands, off the coast of Pigeon point, are wholly in the Animikie, consisting of hardened slates and of great dikes of gabbro that run nearly east and west. In the midst of the disturbances which they have suffered some of the strata have been fused, both on Pigeon point and amongst these islands, and red granite and quartz-porphyry have resulted. Indeed, one or two of these islands consist wholly of such red rock. It is proba-

bly for this reason that Irving, who put such amongst his Keweenawan, in Wisconsin as well as in Minnesota, included some of these islands in that formation, although, as now known, these felsytes and granites are principally, if not wholly, pre-Keweenawan. The northern rim of the great synclinal, therefore, is a persistent feature. When the dip of the Keweenawan and Animikie appears reversed a different great synclinal is expressed. But so far as known, throughout the Lake Superior region this dip is not reversed. It is always toward the great basin. This structural fact again causes it to appear improbable that the horizontal sandstones of Black bay, which lie north of the northern rampart and non-conformably upon the Animikie, are an integral part of the Keweenawan. Irving put them in the base of the Keweenawan, probably because of the great quantity of diabase with which they are associated, apparently not apprehending the fact that the strike of those beds is further south with a considerable dip to the south, and that it would not be possible for them to reverse their dip within the interval (about 18 miles) without manifesting it at some place above the surface of the lake.

If this inquiry be carried further, it will be necessary, in the next place, to examine into the nature of these rocks themselves.

Dr. Robert Bell has given very full descriptions of them in several reports of the Geological Survey of Canada.* Lithologically he regarded them comparable with the Permian or Triassic. They consist of light-colored sandstones, often argillaceous, sometimes reddish, marls and limestones. When the writer examined them in 1879, on the mainland north from Silver Islet he was impressed with the aspect of recentness which they present, in contrast with all the other rocks of the region.† They lie there in a deeply eroded place in the horizontal Animikie slates of the region. On Thunder cape the Animikie slates rise about 1,000 feet higher, lying horizontal, or having a dip of a few degrees into the lake. In this eroded depression these later sandstones and marls lie, also about horizontal, non-conformably on the Animikie, their base being a conglomerate hardly more indurated than the sandstones and marls above, and in great contrast with the basal conglom-

*Report for 1866-69, pp. 313-364; ditto 1873-74, p. 97.
†See 10th Report, Minnesota Survey.

erate of the Keweenawan or of the Animikie. This conglomerate consists largely of red felsyte pebbles, often as large as walnuts, and of white quartz. These can of course be referred to the Animikie underlying which abounds in red felsytes and in taconyte cherts. Bell mentions traces of fossils, and reports the statements of Indians and others that fossils occur abundantly in a limestone farther north, which, however, was beyond the range of his instructions. The facts seem to warrant a lithological comparison with the "Eastern sandstone" of the south shore.

Thus, structurally, geographically, stratigraphically and lithologically, they seem to be the northern representative of the Eastern sandstones. But they are interbedded and covered by copious trap sheets, a circumstance which doubtless has led to their being included by Logan in the "upper volcanic group" of his "upper copper-bearing series," an assignment which has been followed by all geologists.

That these diabases were not cotemporary with the sediments with which they are now associated is made evident, however, by Dr. A. C. Lawson,* and therein they show another remarkable divergence from Keweenawan characters. He points out that the *Logan sills* of the Animikie are also the diabase sheets and caps of these sandstones, and date from an intrusion later than the sandstones. He suggests that they may be as late as the trap dikes which in Mount Royal (Montreal) cut through the Trenton limestone. Following are the characters which show they were not surface flows of molten rock like those of the Keweenawan, but are intrusive sheets which penetrated the formation and insinuated themselves between the beds after the strata were formed. They are thus enumerated by Lawson. He applies these statements to the Animikie sills, but as he says the trap sheets of the sandstone are of the same age and are visibly continuous from the Animikie to the sandstones, they are applicable to the sandstones.†

They are not volcanic flows because:

1. They are simple geological units, not a series of overlapping sheets.

2. They are flat with uniform thickness over areas more than one hundred square miles in extent, and where inclined the dip is due essentially to faulting and tilting.

*Bulletin VIII, Minnesota Geological Survey.

†Op. cit., p. 45.

3. There are no pyroclastic rocks associated with them.
4. They are never glassy.
5. They are never amygdaloidal.
6. They exhibit no flow structure.
7. They have no ropy or wrinkled surfaces.
8. They have no lava-breccia associated with them.
9. They came in contact with the slates after the latter were hard and brittle, and had acquired their cleavage: yet they never repose upon a surface which has been exposed to sub-aerial weathering.

They are intrusive because:

1. They are strictly analogous to the great dikes of the region. (*a*) In their general relations to the adjacent rocks, and in their field aspect. (*b*) In that both their upper and lower sides of the sheets have the facies of a dense aphanitic rock, which grades toward the middle into a coarsely crystalline rock.
2. They have a practically uniform thickness over large areas.
3. The columnar structure extends from lower surface to upper surface, as it does from wall to wall in dikes.
4. They intersected the strata above and below them after the latter had been hard and brittle.
5. They may be observed in direct continuity with dikes.
6. They pass from one horizon to another.
8. The bottom of the sedimentary strata above them, wherever it is observable, is a freshly ruptured surface.
9. Apophyses of the trap pass from the main sheet into the cracks of the slate above and below.
10. The trap sheets, particularly at the upper contact, hold included fragments of the overlying slates.
11. They locally alter the slates above and below them.

An intrusive rock may appear at the surface and become a lava flow at other places. The writer has been unable to find any description of the individual localities of these diabases, in the region here considered, which mentions any amygdaloidal structure or other characters of eruptive surface rocks. Robert Bell, however, in his summary section of the rocks of Thunder and Nipigon bays,* mentions layers of trap between conglomerates and sandstones, mostly of a light color, which are "often amygdaloidal," occurring on the east side of Black bay. In the special description, however, of the east side of Black bay such characters are not mentioned and it is left to be inferred that in making up the generalized section this character was added as one of the usual features of the Keweenawan traps, based on what the author knew of those traps in general, since he describes these sheets uniformly as

*Geological Survey of Canada, Report for 1866-69, p. 320.

surface flows cotemporary with the sedimentation, wholly analagous to those of the Keweenawan.

Whether these horizontal sandstones are involved with the tilted sandstones which form the southern extremity of cape Mamainse, at the eastern end of lake Superior, is difficult to ascertain from the description of Mr. Thomas Macfarlane.* That there are "horizontal sandstones" further south, which extend to Sault Ste. Marie, is generally admitted.

There is but one point further to be mentioned going to show the later date of these Black Bay traps. Without including the peculiar dips and alternations of the sandstone beds at Mamainse, it cannot be questioned that the "horizontal sandstones" have been tilted locally since they were deposited. Such violent rupturing and bending as Sweet and Chamberlin and Irving describe and illustrate, the former in Douglass county, Wisconsin, and the latter along the southeastern side of Keweenaw point, imply profound movements in the deeper seated portions of the rocky crust. It is reasonable to suppose, as Chamberlin and Irving have, that movements once begun along a line of weakness would be liable to recur there at later dates. Since they have recurred at later dates it may be inferred that their origination and recurrence have a common cause. Their origination was intimately connected with the fractures that marked the growth of the Lake Superior synclinal, and the outpouring of trap rocks. Their recurrence, therefore, must have had the same deep seated connection with that movement. In other words, the fractures and thrusts which are seen in the horizontal sandstones on the south side of the lake, not accompanied by trap outflows so far as known, may have been accompanied by such phenomena on the north side, since on both sides of the great basin the rim would be likely to feel the effect of the settling at the center.

In fine, although it may not be considered as altogether demonstrated that the Black Bay sandstones are no part of the Keweenawan proper, there is so much evidence tending that way that for the purposes of geological correlation the rational observer is compelled to accept it as probable, and to construct his taxonomy on that evidence as the most likely foundation.

*Geological Survey of Canada, 1866.

THE UPPER SILURIAN IN NORTHEASTERN IOWA.*

By A. G. Wilson, Hopkinton, Iowa.

The literature on Upper Silurian formations in Iowa is not very extensive. In D. D. Owen's report of 1840, relating to the mineral lands of Iowa, Wisconsin and part of Illinois, the Niagara formation and Galena limestone were classed together under the name of Upper Magnesian limestone.

The Maquoketa shales between the Niagara and Galena were not observed by Owen. The Cliff or Upper Magnesian limestone, however, he divides into the upper, middle and lower. As the middle and lower are said to be rich in lead and zinc, the upper must have been what is now known as the Niagara. This is characterized as follows:† "More regularly stratified and less frequently vertically fissured than the middle and lower, also more rich in siliceous fossils; containing layers of chert and indeed passing sometimes wholly into masses of flinty rocks; containing also good iron ore and much crystallized carbonate of lime, but lead rarely and in unprofitable quantities." He says further that these upper beds contain casts of Terebratulæ, which, from his description and figures, appear to be *Pentamerus oblongus* Sowerby,‡ and various names are given for corals now known as *Halysites catenulatus* Linn., *Ptychophyllum expansum* Owen, *Lyellia glabra* Owen, *Strombodes mammilaris* Owen, *Strombodes gigas* Owen, and various others. None of the Iowa reports since that date (except the reprint of this one in 1844) has figured any fossils from the Upper Silurian.

In Dr. Owen's much larger report in 1852 on Wisconsin, Iowa, Minnesota and part of Nebraska, this Upper Magnesian or Cliff limestone is passed over without so much as a mention. In the map accompanying this report, however, he called this terrane the Coralline and Pentamerus beds of the Upper Magnesian limestone, indicating also that it is the equivalent of the Clinton and Niagara groups of the Upper Silurian, while the lead bearing beds are placed in the Lower Silurian in his table of colors.

In Hall's report on Iowa in 1858 three formations are described as representing the Upper Silurian, viz., the Niagara,

*Read before Section E, A. A. A. S., Springfield, 1895.
†Op. cit., p. 24.
‡See pp. 66, 121.

the Le Claire and the Onondaga salt group. The Niagara is said to be recognized by the fossils *Halysites catenulatus* and *Pentamerus oblongus*. The Le Claire is said to be* "Gray, or whitish limestone, sometimes yellowish on fresh fracture. The whole mass is semi-crystalline and very porous, from solution and removal of fossils. It is sometimes so extremely and uniformly vesicular as to resemble the porous lavas or amygdaloids. The surface is harsh to the touch and on fresh fracture has the sharpness and harshness of a siliceous rock. It would nevertheless appear to be a magnesian limestone, but is reputed to make the best limestone in that part of the country." The fossils reported are a small *Spirifer*, a *Spirigera* or *Athyris*, a *Pentamerus* indistinguishable from *P. occidentalis*, several gasteropods and some chambered shells. He adds that no complete collections were made. The Onondaga salt group or Salina formation is described as an evenly bedded, drab colored limestone, which affords rock for building purposes.

In the American Journal of Science for May, 1862, A. H. Worthen stated it as his opinion that the formations called Onondaga and Le Claire by Hall were identical and that their characteristic beds were found intercalated, and that they represented the upper Niagara. In the New York Regents' report of 1864 Hall stated it as his conclusion that the Le Claire was of Niagara age, but still maintained that the beds he had called Onandaga overlie the Le Claire. In White's report† these representatives of the Upper Silurian are all placed under the title of Niagara group, Hall's Le Claire being mentioned as synonymous in part, and the Onondaga or Salina is not mentioned at all.

In McGee's Pleistocene history of northeastern Iowa,‡ after the statement that Norton maintained Hall's division into Niagara and Le Claire, the opinion is expressed that, as no unconformity is known and as the successive strata unquestionably represent continuous deposition, it is inexpedient to divide the series.

In the Iowa report for 1892 a photographic plate is given showing apparent unconformity between the upper and middle

*Hall's Geology of Iowa, vol. 1, part 1, pp. 73, 75.
†Geol. of Iowa, 1870, vol. 1, p. 182.
‡Eleventh Annual Rep. U. S. Geol. Surv., 1889-90, p. 325.

members, though it is stated in the text that this may be only false bedding. In this report Keyes says,* "The exact subdivisions of the Upper Silurian rocks in Iowa are yet somewhat unsettled. * * * With the exception of White, [McGee's memoir had not yet appeared] all geologists who have examined the Upper Silurian strata in Iowa regard the rocks as made up of at least two distinct formations. At present these subdivisions differ greatly, not only faunally, but in a less marked degree in their stratigraphical and lithological characters. For reasons set forth above, Hall's Le Claire seems a desirable name for the upper member as now understood, while Niagara, for the present, will be retained for the lower."

In the report last quoted there is also an article by G. L. Houser on "Building Stones and Limeburning Dolomites of the Niagara in Iowa."† The subdivisions recognized in this are the upper Niagara, affording the building stone, and the middle Niagara, said to be the best for lime; thus implying that there is a third or lower member. An article by J. P. Farnsworth in the AMERICAN GEOLOGIST for Nov., 1888, pertaining to the Niagara in Iowa does not mention subdivisions of the group, neither do two articles by Calvin on fossils of the Niagara in the AMERICAN GEOLOGIST for July and August, 1893.

The object of this paper is to state the result of a study of these rocks which has extended over several years, with an attempt to describe the subdivisions as they appear in countless outcrops in Delaware, Jones, Dubuque and Clayton counties.

The basal member of the formation, as determined by outcrops of the Maquoketa shales beneath, is well exposed at the following places: (1) at Rockville, Delaware Co.;‡ (2) two miles northeast of Colesburg; (3) on a branch of Elk creek, five miles northeast of Greeley; (4) in the Mississippi bluffs near Sabula.

This basal portion, for which Calvin has used the term "beds of passage," is composed of thin bedded, non-vesicular, buff colored dolomite, the layers being from one to three inches

*P. 30.
†Op. cit., p. 203.
‡See article by Calvin, Proceedings Iowa Acad. Sci., 1894, p. 40.

in thickness, often having thin layers of chert intercalated, and making up as much as one-third of the mass. Fossils appear to be entirely wanting. Above about twenty feet of this rock there are usually two or three layers of heavily bedded dolomite, soft, porous, brownish yellow, with imbedded chert nodules; then more thin bedded layers of a white or light gray color, with scattered nodules of chert. This basal member is from 30 to 50 feet in thickness and can probably be recognized only by its stratigraphical and lithological characteristics.

The second member may for the present be called the lower Coralline beds. The rock is at the base softer, more vesicular, darker buff, scarcely crystalline, heavily bedded and contains *Lyellia glabra* Owen, *Halysites catenulata* Linn., *Syringopora verticellata* Goldfuss, and species of *Favosites*, with perhaps a few other corals. Toward the upper part the layers usually become thinner, harder and more compact, and considerable chert is found. These lower Coralline beds are usually 25 to 30 feet in thickness. These two lower members are useless for lime or building stone, except for bridge piers, mill dams and footing rock, though they furnish good road materials.

The next higher member is what has long been known as the Pentamerus beds. These are from 70 to 80 feet in thickness. The texture at the base is like that of the top of the lower Coralline, the rock being grayish in color, compact and hard, with splintery fracture. Toward the middle the matrix becomes much softer, a brighter yellow, scarcely crystalline, quite free from chert and very vesicular. The characteristic fossil, *Pentamerus oblongus* Sowerby, is not abundant at the base and is of rather small size. Toward the middle the individuals are generally larger and often almost the whole mass is made up of this fossil. Toward the top this species becomes smaller and is comparatively rare, and is accompanied in places by *Pentamerus pergibbosus* Hall and Whitfield. These beds also contain *Cerionites dactylioides* Owen, *Halysites catenulatus* Linn., *Atrypa reticularis* Linn., *Atrypa nodostriata* Hall, *Strophomena rhomboidialis* Wilckins. The uppermost 25 or 30 feet of the Pentamerus beds resume the texture of the basal portion, becoming generally much harder and more flinty, often showing on fresh fracture a steel gray color

and often striking fire with the hammer, yet being quite free from chert nodules.

Numerous vertical dry joints, of short extent and roughly parallel, and trending generally east by south or at right angles to this, give a characteristic appearance to a weathered surface and cause bluffs to wear away rather rapidly from the splitting off of huge vertical slabs. The top layers are very heavily bedded, a single layer measuring often from ten to twenty feet in thickness. A decided change in the fauna also takes place, showing a predominance of univalves and crinoids. *Cerionites dactylioides* Owen, becomes more abundant. *Orthoceras* occurs in numerous species, as do also *Phragmoceras*, *Gomphoceras* and *Cyrtoceras*. A small species of *Conocardium*, a small *Spirifer*, a large *Bellerophon* three inches in diameter of coil, *Pisocrinus gemmiformis* Miller, several other crinoids and several species of *Straparollus* also occur. It is this upper portion of the Pentamerus beds that furnishes the best material for lime and it has been very generally used for that purpose.

At the summit of the Pentamerus beds, there is an abrupt change in both the lithological and faunal features. In bluffs, when the two are in contact, the dividing line can generally be easily traced. The contact may be seen in the bluffs of the south fork of the Maquoketa river in Delaware county, in the S. W. ¼ sec. 24, T. 87, R. 4; at Flemming's mill, N. W. ¼ sec. 29, T. 88, R. 4; at Hartwick in N. W. ¼ sec. 30, T. 88, R. 4; in the bluffs of Buck creek in the south part of sec. 9, T. 87, R. 4; and in the N. W. ¼ of sec. 18, T. 87, R. 2, of Dubuque county.

The overlying member has been known as the Coralline beds. The rock becomes softer and generally shows thinner bedding. The fracture is earthy, the texture is in part crystalline and in part coarsely granular. The system of dry joints is no longer seen, nor is the steel gray color observed on fresh fractures. The weathered surfaces are no longer covered with sharp projecting points and edges, nor filled with amygdaloid cavities, but show rounded surfaces and irregular lines of fracture. When these two members form the land surface, the upper part of the Pentamerus beds tends to assume a flat tabular form, covered with angular blocks, while the Coralline

forms dome shaped knolls covered with rounded fragments. The fossil *Pentamerus* seems to be entirely wanting in the Coralline beds. In the AMERICAN GEOLOGIST for August, 1893, Calvin has mentioned some of the principal fossils of this horizon. They include *Ptychophyllum expansum* Owen, *Strombodes gigas* Owen, *Plasmopora astraformis* Owen, and *Lyellia glabra* Owen. In addition to these might be named *Favosites niagarensis* Hall, *F. hispidus* Rominger, *F. hisingeri* E. & H., *Syringopora verticellata* Goldfuss, *Zaphrentis stokesi* E. & H., *Orthis flabellites* Hall, and several species of *Alveolites* and *Stromatopora.*

These upper Coralline beds are estimated at 40 to 60 feet in thickness.

The beds that succeed the upper Coralline are the ones that have so often been described as the building stone of the Niagara. A good general description of these is quoted from McGee's writings, by C. R. Keyes in the Iowa report for 1892, page 31. They may be generally recognized by their very even bedding, buff or bright yellow color, compact fine-grained texture and the general absence of lustre due to crystallization. Chert layers are usually present, especially in the upper portion. Near Manchester these beds are of a decided blue or even purple color and nearly free from magnesium, but they are generally dolomitic elsewhere. The layers range in thickness from two or three inches, making rock adapted for flagging, to two feet or more. A system of joints trending about S. 70° E. is generally present. Very little seems to have been written about the fossils of these beds in Iowa and the fossils are less numerous than in the Pentamerus and upper Coralline beds. They comprise *Pentamerus oblongus* Sowerby, *Huronia vertebralis* Stokes, numerous species of *Orthoceras*, *Illænus daytonensis* Hall and Whitfield, *Calymene niagarensis* Hall, a few crinoids, *Lituites* and other coiled cephalopods. These building stone beds are from 40 to 60 feet in thickness.

Contacts between the Upper Silurian and Devonian rocks may be seen at Fayette and on the banks of the river midway between Coggon and Central City. In the last named place the rock lying immediately under the Devonian is a buff, heavily bedded dolomite, barren of fossils and so little indurated that in places it can be easily dug with a spade. It

strongly resembles a fine-grained sandstone. It shows the even bedding of the building stone and also the same absence of cavities. This and the heavily bedded dolomite underlying the transition layer at Fayette are believed to be the equivalent of the building stone above described.

The total thickness of these beds according to these estimates would be 200 to 280 feet. Deep wells show a thickness at Cedar Rapids* of 285 feet; at Tipton, 325 feet; at Davenport, 320 feet; at Ottumwa, 150 feet; at Ackley, 115 feet; at Vinton, 100 feet. At Monticello the well begins in the upper Coralline beds and the thickness of the Upper Silurian is 185 feet. At Manchester also the well begins in the upper Coralline beds and shows about the same depth to the Maquoketa shales. At Hopkinton a well beginning at the top of the Pentamerus beds shows a depth of 160 feet to the shales.

The characters given here for these five divisions are believed to be sufficient for identifying the respective beds in this portion of Iowa; and they are given with the hope that they may aid in leading to a better understanding of the relation of the Iowa Niagara to that of neighboring states. These characters may be of use locally in indicating the presence or absence of building stone or lime burning stone; and as water is almost sure to be found at the upper surface of the Maquoketa shales, this may furnish the means of calculating its depth below the surface.

It will be seen from the foregoing that there are cycles or alternations of sedimentation in this formation. It begins with large quantities of chert in the transition beds below, and the summit of the building stone returns to the same character, while the intervening beds are comparatively free from chert. The lower Coralline strongly resemble the upper Coralline beds, lithologically and faunally, while the intervening Pentamerus beds have a fauna much like that of the building stone which overlies the upper Coralline.

HIGH LEVEL GRAVEL AND LOAM DEPOSITS OF KENTUCKY RIVERS.

By Arthur M. Miller, Lexington, Ky.

The waste of Carboniferous rocks occurring in the upland soil of the Blue Grass region has frequently attracted the at-

*See article by W. H. Norton, Ia. Geol. Rep., vol. III, 1893, pp. 186, 208.

tention of Kentucky geologists, and has generally been urged as an evidence of the former wide extension of the Carboniferous rocks over a great part, if not all, of central and northern Kentucky. According to this view the eastern and western coal fields were one time continuous across the now well defined Cincinnati anticline, and the present exposure of the lowest Silurian strata nearest the axis of this anticline has been brought about by the extensive denudation since the close of the Carboniferous age.

While not attempting to dispute this latter proposition—the successive lines of retreating geological escarpments, with "outliers" of the newer formations far within the encircling boundaries of the old, point strongly to this conclusion—yet it has been forced upon me that there is perhaps another and better explanation of the *loose* "waste" of the Carboniferous far up on the flanks and even on the crest of this anticline.

This "waste" consists for the most part of hard materials, the quartz pebbles from the basal Coal Measure conglomerate, silicified Lithostrotion corals from the St. Louis limestone, and quartz geodes from the upper Waverly or Keokuk. Now and then, however, some of the softer Coal Measure sandstones and even pieces of coal occur in exactly the same situations. Moreover, all these show evident signs of being river worn, and, accompanied as they frequently are, by deposits of beautifully stratified sand and clay, they lead one to the conclusion that they have gotten into their present positions mainly through the action of running water. Again, the facts that these materials are more abundant near the rivers (four miles back is about the maximum limit in the Blue Grass region) and are not found upon the tops of the highest hills (350 feet above the present channel seems to be the upper limit), nor along those watercourses, whose fountain heads are not within the eastern coal field, preclude the idea that they have been let down into their present positions as the residual products of subaerial decay.

Prof. G. F. Wright, in his discussion of the "Cincinnati glacial dam hypothesis," makes mention of the finding of these gravels with occasional pieces of coal at high levels along the Licking river, both near the mouth and as far up as Slate creek in Bath county. Shaler makes mention of similar

deposits in the lower course of this stream, back of Newport 300 feet above the river and at Flatwoods 11 miles further up stream. They occur at other points, as at Upper Blue Licks in Flemming county, where Coal Measure conglomerate pebbles were noticed as high as 300 feet above the river (875 feet, barometric, above tide). No traces of pebbles could be found in the soils at corresponding hights on the North fork of the Licking, where it is crossed by the Maysville and Lexington pike. The North fork does not tap with its headwaters the conglomerate region, and this seems a sufficient reason why evidence of a former submergence is wanting. The stream was not supplied with materials resistant enough to line off ancient high water levels.

The evidences of the former flooded condition of the Kentucky river are of the same character. Wherever search has been made for them, they have been found. At Waco in Madison county, on Devonian black shale uplands, four miles from the river and at a probable elevation of 300 feet above it (850 feet above tide). are deposits of sand and clay beautifully stratified. Farther down the river, near the mouth of Marble creek, on the Jessamine county side, at about the same elevation (850 feet), the upland soils are strewn thickly with Coal Measure conglomerate pebbles, the same as seen on the Licking, and some Subcarboniferous geodes. Again, near the southern limits of this county, near Little Hickman post office, and also near Camp Nelson, where the river reaches its extreme southern deflection in its efforts to cross the Cincinnati axis—right upon the summit of the anticline in fact—are found waterworn Keokuk geodes, blocks of Coal Measure sandstone as large as 18 inches in diameter and these same conglomerate gravels. The latter extend up to a hight of 350 feet above the river (850 feet above tide),—to the very top, in fact, of the cañon-like gorge which the river is forced to make in cutting its way across the backbone of the arch. Above Little Hickman post office the Kentucky River fault leaves the river to the southeast, and, following down Big Hickman creek, cuts off a large bend of the river, which is four to six miles across. The more rounded hills of the lower and middle Hudson River beds, brought down on a level with the Birdseye by this fault, are included in this bend. They are everywhere

thickly strewn with these gravel and boulder remains and a sand deposit occurs similar to that at Waco. The boulders occur to a hight of 200 feet above the river. With one exception, all the materials seem to be of Carboniferous origin. The exception noted was a hard quartzite boulder measuring 14 by 8 by 5 inches; and it had every appearance of the Canadian quartzites found so abundantly in the beds of southern Ohio streams near the margin of the drift. The hight of the hills, 850 feet above tide, has not been quite great enough to render their tops entirely free from pebbles. Sixty-five miles farther on in the sinuous course of the stream (25 miles in an air line), at Tyrone on the western flank of the anticline, where the river, after rounding the anciently obtruded barrier, again resumes the wonted course of Kentucky rivers—toward the northwest—the same high level conglomerate pebbles were sought for and found at their proper hight. The evidence seems conclusive, that the Kentucky river, as its sister river the Licking, was within comparatively recent times flooded out over its banks to a level that was, for its lower course, from 300 feet to 350 feet above its present channel, or to something like 875 feet above sea level.

The glacial dam hypothesis, which has been urged to explain the terrace phenomena of the Ohio River valley above Cincinnati, might also seem the most reasonable one here; and if we had only the Kentucky river to deal with, "lake Kentucky" might be added to "lake Ohio." The terminal moraine is platted by Wright as crossing into Trimble county, Ky., below Carrollton. This could give us an ice dam blocking the mouth of the Kentucky as effectually as did that at Cincinnati the mouth of the Licking and the upper course of the Ohio. We may, upon this assumption, by tracing the contour of 875 feet, approximately determine the outlines of this "lake Kentucky." It would be long and narrow, hardly getting outside the confines of the strip of river hills about four or five miles back on either side, because the Kentucky river for a great part of its course flows far below the present level of the country in a cañon-like gorge. Evidence may be forthcoming that the river was flooded to a higher level than this, as high as Prof. Wright claims for his lake Ohio, in which case the two lakes were probably continuous, at least

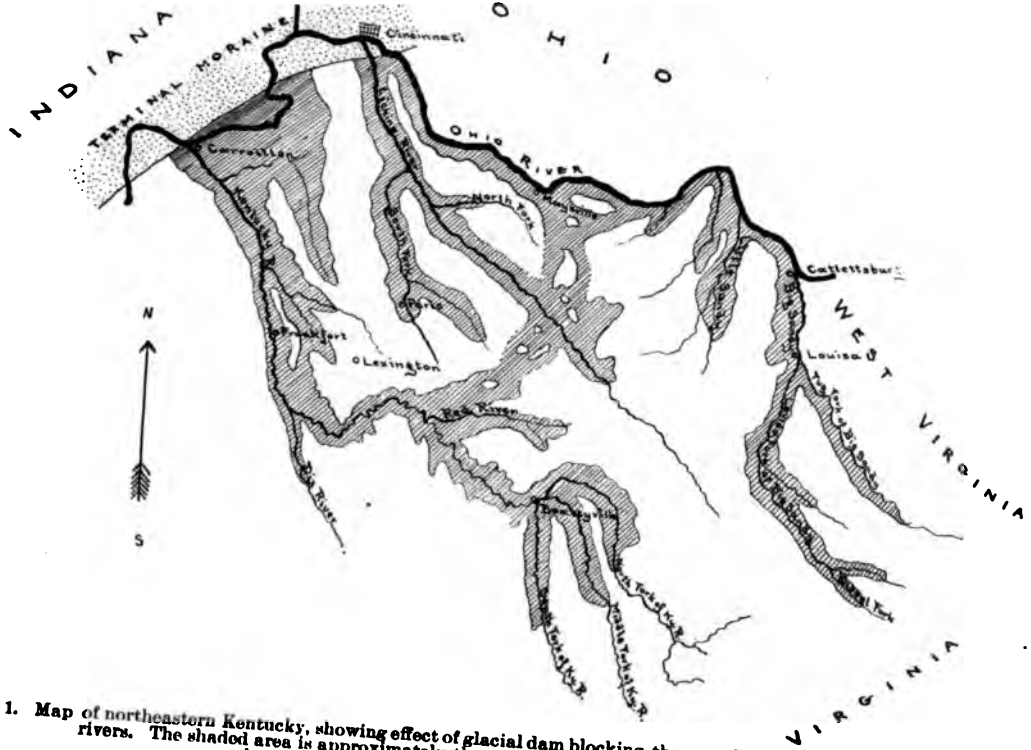


FIG. 1. Map of northeastern Kentucky, showing effect of glacial dam blocking the mouths of the Licking and Kentucky rivers. The shaded area is approximately the portion submerged as indicated by the highest observed level of river gravels, 875 feet above the sea level.

along the ice front; and there are indications that the 875 foot level would establish a water connection along the foot of "the knobs" from Vanceburg through the eastern part of Flemming, Bath, Montgomery and Clark counties. Sufficient topographic data are wanting to establish this point conclusively; but the falling off of the land with the dip along the eastern flank of the Cincinnati anticline is very pronounced, so that the Waverly formation rises abruptly into knobs 1,100 to 1,300 feet above sea level, from a Devonian black shale base that is about 700 feet above the same datum line.

The accompanying provisional map is constructed with a view to showing the probable flooding effect of a glacial dam following the line of the terminal moraine in its southwest trend through northern Kentucky.

That such a dam would account for the phenomena described seems a reasonable hypothesis, and if limited to the rivers mentioned might receive more than a provisional acceptance. How is it with the Green and Cumberland rivers? With a view of determining this a special trip was taken recently to the headwaters of the Green river and to the Cumberland river where it emerges from the Cumberland plateau. Green river barely reaches a hight of 1,000 feet above the sea, and that only at the base of Green River knob, where one of its head tributaries rises. It lies the lowest of the four great rivers of Kentucky whose courses lie mainly or wholly within the boundaries of the state. Chester sandstone caps the top of this knob. It is almost the extreme eastern limit in the reach of this formation. There is no trace of the conglomerate here or of its having been here. In keeping with this fact, no quartz pebbles could be found in the same relative situation as on the Kentucky and Licking. The evidence of submergence here is largely of a negative character, unless the "hill top silicified fossils," referred to by Shaler as evidence of extensive denudation, have a different interpretation.

Crossing over to the Cumberland in the vicinity of Mills Springs, the evidence of submergence becomes very pronounced. A yellowish red sandy loam filled with quartz pebbles was found covering all the country back from the river several miles. The highest level noted for these deposits was 300 feet above the present stage of water (880 feet above

tide). The flood-plain character of the country is even more pronounced on the other side of the river. There, extending back ten miles or more—to the very base of the Cumberland plateau, in fact—and covering quite deeply in places the lower 100 feet of the St. Louis limestone, are extensive deposits of this reddish or orange sandy loam, pebbly throughout. The hight of this beautiful valley ranges between 850 and 1,000 feet above the sea, with the present Cumberland winding through it in the deep gorge 200 to 300 feet below. The edge of the plateau rises rather sharply from the valley with a lower 300 foot slope of upper St. Louis limestone, succeeded by 100 feet of Chester sandstone and shales, and is surmounted by a 200 foot precipitous escarpment of Carboniferous conglomerate. This has probably been a line of retreating escarpment for ages, but the pebbles now strewn far and wide over this valley never owed their present position solely to the slow action of atmospheric decay. The slopes of this escarpment, and the tops of the limestone hills above 1,000 feet show scant traces of quartz pebbles, though blocks of conglomerate are common. Below this level the evident fluvial deposits set in.

There is an evident similarity between the deposits of the Licking, Kentucky and Cumberland rivers, these deposits increasing in thickness in the order named. The reddish-yellow loamy character is more pronounced on the Cumberland, but it is not wanting on the Kentucky. These facts, so far as they point to a community of cause for the submergence, militate somewhat against the glacial dam hypothesis. Still the terminal moraine is not far to the north of the mouth of the Cumberland at the point of its most southern sweep in Illinois, and further investigation may reveal the fact that it was in some way responsible for the flooded condition of this river also. More facts must be collected, and especially must observations be made at the mouths of these and other rivers emptying from the left bank into the Ohio river below Cincinnati, before the glacial dam theory can be either set aside or sustained.

ORIGIN OF THE IOWA LEAD AND ZINC DEPOSITS.*

By A. G. LEONARD, Toledo, Iowa.

The Iowa lead and zinc deposits occur in the northeastern corner of the state and form part of a larger area known as the Upper Mississippi lead and zinc region to distinguish it from the Lower Mississippi or Missouri region. The Upper Mississippi area has a length east and west of 96 miles and a width north and south of 55 miles, embracing the southwest portion of Wisconsin, northwest corner of Illinois and adjoining parts of Iowa. This region, embracing some 3,000 square miles, lies wholly within the limits of the driftless area.

As is well known, the lead and zinc occur in crevices in the Galena and Trenton limestones. These formations are cleft by extensive east and west fissures, which at certain depths are found to expand into cave-like "openings;" it is in these openings that a large portion of the ore occurs. In Iowa the first and largest "opening" is as a rule about 45 feet below the top of the Galena beds and most of the ore has been taken from the upper fifty or sixty feet of the limestone.

The question of the origin of the lead and zinc deposits has been under discussion ever since the days of Owen and Percival and has recently come into renewed prominence through the work of Winslow, Jenney, Blake and others. New light has been thrown upon the subject, new theories advanced and old ones reaffirmed.

In treating of the genesis of these deposits it will be well to consider in the first place the original source of the lead and zinc and the way in which the ores came to be confined to certain districts, and then to discuss the formation of the crevices and the deposition of the ores in these receptacles.

Original source of the lead and zinc. For the source whence the minerals were originally derived we must doubtless look to the primitive Archean rocks forming the land mass to the north. As this land was wasted away and its materials carried into the Silurian sea, the waters became charged with metallic salts which were deposited along with the limestone. The chief agent in the precipitation of the metals appears to have been the organic life so abundant during this period. The death and decay of the vast multitudes of mollusks and

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other forms gave rise to gases which were doubtless very effective in precipitating the metallic sulphides, which were thus deposited along with the sediments.

Localization of the deposits. One fact in connection with these deposits is difficult of explanation on the theory of oceanic deposition, namely, the localization of the ore bodies. These bodies are confined to certain districts, outside of which the ground is nearly or quite barren, although as far as can be seen the conditions are quite as favorable. For example, the Dubuque mines are confined to an area of some twenty square miles, while to the north and south the Galena limestone carries no ore though everywhere cut by numerous crevices favorable for its reception. The same is true of the many mining districts of Wisconsin and Missouri. The mines are noticeably grouped about certain centers while the surrounding country is unproductive. The natural supposition would be that the minerals were everywhere equally disseminated through the rock and that they have been leached out and deposited in the fissures only in certain favorable localities. But this is hardly probable in view of the fact that the conditions are apparently just as favorable for the formation of ore bodies in the barren districts as in the productive ones. How then can we account for the localization of the deposits on the generally accepted theory that the lead and zinc were contained in the oceanic waters and were distributed through the rocks at the time of their formation?

Professor J. D. Whitney* over thirty years ago published an elaborate report on the lead region and discussed at considerable length the origin of the deposits. His views differ quite radically from those of Messrs. Owen and Percival, who had maintained that the metals were derived from great depths. Professor Whitney was the first to advance the theory that the metallic salts were held in solution in the waters of the ancient sea and were thrown down by organic matter or by the sulphuretted hydrogen arising from its decay. But no satisfactory explanation was given for the localization of the lead and zinc.

Professor T. C. Chamberlin† attributed the original concen-

*Geol. of Wisconsin, 1862.

†Geol. of Wisconsin, Survey of 1873-1879, vol. IV, p. 529,1882.

tration of the deposits to the currents of the old Silurian sea. The oceanic waters impregnated with metallic salts derived from the leaching of the adjacent lands were borne by currents to areas where there was an abundance of organic life, in the presence of which the metals would be extracted and thrown down along with the sediments.

Mr. Arthur Winslow* has recently advanced a somewhat different hypothesis concerning the origin of the Missouri ore bodies. He holds that the concentration is due to the surface decomposition of the rocks. "According to our theory the concentration is entirely secondary. It is primarily a result of great and long-continued surface decay of the rocks; and secondarily, the result of the presence of local favorable, physical and chemical conditions." The hypothesis starts with the proposition that the minerals existed in the Archean rocks, and with the decay of these became diffused through the later formed sediments. It will be noticed that this theory agrees with that of Chamberlin in recognizing the presence of minerals in the country rocks and the derivation of the deposits from them; but it differs in maintaining a condition of general diffusion, rather than one of concentration, over certain favored areas.

The evidence is abundant that very extensive sub-aerial decay has befallen the rocks in the Missouri region, and during successive geological periods many hundreds of feet have been removed. Mr. Winslow believes that in the Wisconsin-Iowa area the same processes were long operating to concentrate the ores. It has already been stated that the district is unglaciated, and thus has been long exposed to atmospheric agencies by which the rocks were extensively decomposed.

Mr. W. P. Blake,† who is familiar with the Wisconsin deposits, seems to hold something of the same view as Winslow, if we may judge from the following words: "The evidence is strongly in favor of the view of the long-continued decomposition, downward flow and re-composition of not only the ores of zinc but of lead and of the pyrite from the upper formations to the lower, as the general water-level of the region subsided and as the upper formations by long continued exposure through geologic ages were gradually decomposed in

*Missouri Geol. Surv., vol. VII, p. 477, 1894.

†Trans. Am. Inst. Ming. Eng., vol. XXII, p. 621, 1894.

place. By such a process the present zinc deposits would seem to have accumulated and to represent the originally diffused ores in many formations, possibly as high in the geologic scale as those of Missouri or the Lower Carboniferous. This is, however, improbable, owing to the dense and impervious nature of the intervening Hudson River (Maquoketa) shales."

It would seem that this impervious character of the shales constitutes a serious objection to Winslow's theory as applied to the Iowa deposits. The latter are commonly overlain by these shales and occur mostly near the top of the Galena limestone. Granting that the overlying Niagara and Maquoketa formations were impregnated with lead and zinc, it would hardly have been possible for the mineral-bearing solutions to make their way through the impervious shales. In other words, there could not have been in this area a very extensive downward flow and re-composition of the ores. The process has doubtless been going on within the Galena formation itself and may have caused some local concentration, but the limestone has not undergone very extensive decomposition in situ, and the ore is found largely in the upper beds. For these reasons, while Chamberlin's theory of ocean currents may appear somewhat too hypothetical, it furnishes on the whole the most plausible explanation yet offered for the localization of the Upper Mississippi deposits.

Formation of crevices. Cavities and crevices in rocks are formed in several different ways. They may result from contraction due to solidification, drying or cooling. A familiar example of this process is seen in the cracks found in basalt. It is probable that some of the joints of sedimentary rocks have had the same origin. But the most important cause of fracture is found in the movements of the earth's crust producing a folding and crumpling of the strata. When such anticlinals and synclinals are formed the rocks are fissured by the strain to which they are subjected. Should the walls of the fissure slip over each other, one side being raised or lowered, a fault would result. The fractures when once formed become the channels for subterranean drainage, and these are enlarged and modified by the dissolving power of water.

The crevices of the Upper Mississippi region are apparently due to the second cause. Extending east and west through

the lead district are numerous undulations of the strata. These flexures were doubtless the chief agent in the production of the crevices. As the strata were slowly elevated the heavily bedded limestones were fissured in a direction parallel to the axis of elevation and crevices more or less open were formed. In a direction at right angles little force was exerted and the beds were simply fractured, producing the narrow north and south fissures. It is also possible that the latter may be due to the contraction of the rock as it became more compacted.

It is to be noted that the ore deposits of this region do not occur as fissure veins of indefinite extent in depth, but are in what are known as "gash veins" of limited extent and confined to one rock series.

Filling of the crevices. Two opposite views are at present held concerning the source whence veins have derived their metalliferous contents. (1) It is claimed on the one hand that the minerals have been deposited from hot solutions rising through fissures from profound depths. The solvent power of such waters would be great on account of the temperature and pressure, and they would thus be rich in mineral materials which would be deposited on cooling, or on relief from pressure. This is the view so ably advocated by Professor Franz Posepny in his recent paper on the "Genesis of Ore Deposits"* and it has among its supporters many eminent geologists and mining engineers. (2) Opposed to this ascension theory is that of lateral secretion, according to which the contents of the vein are derived from the wall rock itself instead of from unknown depths. A broad interpretation of the theory does not necessitate the derivation of the minerals from the rocks directly bounding the vein, but admits that they may have been leached out from a considerable distance on all sides. It supposes that there is a free circulation of surface waters through crevices and porous strata, and consequently a ready transfer of solutions would result. These waters may traverse the rocks in any direction and may thus in cases rise and be said to come from below. Or, again, they may flow into the crevice either from the sides or from above. This broad conception of the lateral secretion theory has much in common with the one first named. But it differs from that, however

*Trans. Am. Inst. Ming. Eng., vol. XXIII, p. 197, 1894.

since it does not necessitate the presence of profound fissures or faults, nor the rising of the heated waters through these from great depths.

A third view as to the origin of ore deposits is mentioned by Professor J. F. Kemp.* It is held by a number of careful observers and was brought into prominence by Emmons† in his report on the Leadville region. According to the replacement theory, as it is called, no large cavity is supposed to have previously existed. There is a circulation of ore-bearing solutions which interchange their metallic contents, molecule by molecule, for the substance of the rock. The ore body in this case has no well defined limits but shades off gradually into the barren country rock.

We are now ready to enquire which one of the above theories explains in the most satisfactory way the source of the Iowa deposits. There seems to be little doubt that to the process of lateral secretion is due the deposition of the ores in the crevices and that they have thus been derived from the limestone whence they have been leached by surface waters.

The view that the metal-bearing solutions came from below is strongly advocated by Professor Jenney‡ who holds that the Mississippi valley ores have been deposited by waters rising through fissures.

But there are numerous objections to this theory as applied to the region under consideration, and among them may be mentioned the following: 1. No true fissures extending to great depths have been discovered. 2. Faults are of rare occurrence, and when they are occasionally found have no apparent connection with the deposits. 3. The ores exist only in comparatively small amounts in the underlying Saint Peter sandstone and Oneota limestone, and are almost altogether absent from the Saint Croix or Potsdam formation.

On the other hand there are many facts connected with the mode of occurrence of the ores which go to prove that the waters came from above. Masses of Galena are frequently found suspended from the roof of the openings. These could only have been formed by waters that reached the crevices

*Ore Deposits of the United States, New York, 1895.

†Geology and Mining Industry of Leadville, with atlas, Monograph XII, U. S. Geol. Surv., Washington, 1886.

‡Lead and Zinc Deposits of the Mississippi Valley; Trans. Am. Inst Ming. Eng., vol. XXII, p. 171, 1894.

from the upper strata. A few miles south of Dubuque crevices are met with identical in every respect with the ore-bearing fissures farther north, but instead of carrying lead and zinc, except in small amounts, they are decorated with great numbers of stalactites and stalagmites. The ore deposits of this region have evidently had the same origin as these lime formations, and no one questions the fact that the latter are due to moisture trickling down from above.

In order that the theory of lateral secretion may be well established it must be shown that the metals are diffused through the country rock. The necessary analyses have not been made for the Iowa region, but Winslow in his Lead and Zinc Report* shows that the limestones and crystalline rocks of Missouri do contain small quantities of these minerals. "The amounts of metallic lead vary from about 0.0004 to 0.007 per cent., of metallic zinc from about 0.0002 to 0.018 per cent., and of copper, manganese and barite there are correspondingly small amounts. It thus appears, on this hypothesis, which does not require that the ores should come from the immediately adjacent rocks, that the metalliferous contents of the country rocks are ample to supply the ore deposits."

There is every reason to believe that the Galena limestone of Iowa also contains small quantities of lead and zinc and that these have been leached out by percolating waters and deposited in the crevices. It is not uncommon to find small particles of galena and sphalerite in the different dolomitic formations of the state. In the Oneota small pockets of lead are very common and denote the presence of this mineral in considerable abundance.

THE DEVONIAN SERIES IN SOUTHWESTERN MISSOURI.

By Oscar H. Hershey, Freeport, Ill.

In publications of the Missouri Geological Survey, and in other writings bearing on the stratigraphy of southern Missouri, we find occasional mention of a black shale occurring between the limestones and sandstones of the Ozark series and the Kinderhook group in Stone, Barry, and McDonald counties, Mo., and extending into Arkansas, which has been referred to the Devonian system. This bed of shale is well de-

*Missouri Geol. Surv., vol. VII, p. 478, 1894.

veloped at the town of Eureka Springs, Ark., where it is the chief cause of the emergence of most of the springs at a given horizon; and from this town it has received the name of Eureka shale. Its Devonian age is inferred chiefly from its stratigraphic relations, it being conformable to the base of the Kinderhook group, also well developed in this region.

In portions of Stone and Barry counties, where it has been studied by the writer, it was found to be underlain by strata of limestone, and even a thin bed of sandstone intervened before the top of the Ozark series was reached. From an examination of numerous outcrops the following section has been prepared:

	Thickness.
1. Eureka shale	7 feet
2. Gray shaly limestone	13 "
3. Speckled crinoidal limestone	3 "
4. Basal sandstone	1 "

Where studied by the writer, the Eureka shale consists of a bed of finely laminated, soft, argillaceous shale, generally somewhat calcareous, especially in certain layers. Its color, on exposure, varies from a light green to a dark blue gray; and it is probably, before being exposed to the atmosphere, of a very dark and perhaps even black color. Hence, when penetrated by wells or other excavations, it would be reported as a black shale, while if seen only on exposed surfaces it would be considered a green shale. It is nearly or quite destitute of fossils, hence its paleontologic position cannot be determined with certainty. A characteristic of it is the occurrence of satin spar as a secondary mineral in thin layers and in vertical veins.

The Eureka shale passes downward by interstratification and intergrading of materials into the next division of the Devonian strata in this region, a bed of light brown and gray shaly limestone. The limestone is evenly but rather thinly bedded, and varies locally from a very argillaceous to an almost purely calcareous composition. It also varies greatly from layer to layer, sometimes being a nearly pure limestone, with macroscopically an "amorphous" or non-crystalline texture, alternating with other strata of a distinctly shaly structure. The compact "amorphous" limestone contains no fossils, or only a few scattered here and there; but the more

shaly layers abound in calcareous replacements of various small fossil species, broken crinoid stems chiefly predominating. These are so abundant in places as to give one the impression of a highly fossiliferous formation.

At the base of the shaly limestone there occurs a deposit of limestone a few feet thick, having a similar appearance on exposed surfaces, but which differs from that above in being slightly heavier-bedded, less shaly in structure and composition, and in having a distinctly granular texture. This latter feature is due to its consisting almost exclusively of the dissevered parts of crinoids. These are closely packed as in the Burlington limestone, but it differs from that formation in being composed of the débris of smaller species, and hence the grain is much finer. Moreover, while the bulk of the rock is of a light gray and white color, certain species of crinoids seem to be tinted brown and buff, and these give to the rock a speckled appearance. This rock, then, is a highly fossiliferous limestone; and, if the base of the Kinderhook formation is rightly placed over the Eureka shale, it must be of Devonian age.

Occurring at the base of the Devonian strata in this region, and overlying the dolomites of the Ozark series, is the basal sandstone. This is a very thin but rather peculiar stratum of quartz sand, strongly cemented with calcareous matter. The grains of sand vary in size from exceedingly fine to moderately coarse, and, in addition to the transparent quartz, many irregular particles of chert, white, and of other colors, derived from the cherts of the Ozark series, occur. The most curious of the contained minerals consists of small subangular particles of a hard black quartz, which I have been unable to locate anywhere in the Ozarks, although it is possible that it may be a common chert modified by some process to an opaque black color. Small particles of iron pyrites, besides limonitic stains, are present in the deposit and aid in giving it a color varying from bluish gray through light brown to a very light gray. At the Corner cave in Barry county, where it is best developed and attains a thickness of about one foot, this sandstone is of a white color, cemented by silica, very hard, and grading into an oölitic chert.

That the sandstone does not belong to the Ozark series is known from the fact of its passing across the upturned edges of slightly tilted layers of dolomite in some places in this region; although generally no more than four inches in thickness, it is present over many square miles of territory, and is in contact with different layers of the dolomites in different places. Furthermore, in lithological composition it is entirely unlike any sandstone stratum in the Ozark series. As final proof of its belonging to the overlying series, I may state that, although this sandstone is nearly free from fossils, a few have been found in it having a distinctly Devonian facies.

It will readily be seen that the four divisions of our series were deposited in the same body of water in immediately succeeding periods of time; and I should say that each member or division corresponds to a separate epoch of geologic time, as each certainly indicates slightly different conditions. From a study of the distribution of the series and of certain facts indicating very weak wave action in the body of water, and also from the nature of the deposits themselves, it is very probable, nay almost certain, that they were laid down on the bottom of a broad shallow estuarine basin, occupying a position on the south side of the land mass which then existed through what is now central and southern Missouri, and extending thence far to the northwest up the present Missouri valley.

Through many ages the Ozark series had been subjected to subaërial erosion, and was almost completely baseleveled. A subsidence of the land mass or Missouri continent began sometime during the Devonian era, and, as soon as the lower portions of its broad shallow basin-like valleys had been submerged, the fauna of the surrounding seas invaded these estuaries and formed limestones; and the streams which still flowed on the slowly diminishing land mass brought fine sediment into the estuarine basins at their mouths. Deposits formed in such shallow basins of limited extent are found all around the borders of the Ozark uplift, except on the west where the proper horizon is not exposed and where the land mass continued.

In the particular region under discussion the subsidence lasted throughout the period, as is shown by the overlapping

of each stratum beyond that which is under it. The basal sandstone was formed partly from the residual material left on the surface of the Ozark series when subjected to atmospheric action, and partly from material (mostly lime in solution) brought down by the streams from the land on the north and east. Animal life of forms easily preserved was nearly absent. This constitutes the first epoch.

A deepening and broadening of the basin instituted the second epoch, which was characterized by its abundance of animal life and especially by the prodigious quantities of crinoids and kindred forms which lived and died and gave their débris to make the deposits of this epoch. The basin evidently had free communication with the open sea, and its waters were salt. The streams also which emptied into the sea near this locality must have been remarkably free from sediment of any kind; during the long period required for the accumulation of three feet of crinoid débris, wholly of small species, the amount of sediment brought from the land was very little.

The third epoch was characterized by a still broader but slightly shallower basin, less animal life, or at least more rapid deposition of sediment brought by the rivers from the land, which was deposited as a calcareo-argillaceous mud to harden into shaly and "amorphous" limestones.

In the fourth epoch the basin was still more extensive but yet very shallow, and fine clay sediment was being rapidly deposited, excluding the majority of the animal species which had previously inhabited the basin. The deposits of this last epoch, making up the Eureka shale formation, vary from a few inches to 35 feet in thickness; but I believe that they do not indicate any great length for the epoch.

With the earth movements which inaugurated the Lower Carboniferous age, this region was greatly depressed and the surrounding land surfaces were submerged. Hence the base of the Kinderhook strata, although conformable to the Eureka shale, overlaps it to a vast distance.

The correlation of the several members of the Devonian in this region with the divisions of the system recognized in other states is impossible until the paleontologic contents of these strata have been thoroughly studied and compared with

the faunas of other regions. This paper has been prepared principally for the purpose of drawing attention to the existence of these strata in the southwestern corner of Missouri, and to perhaps induce some competent paleontologist to undertake the task of deciphering the history and meaning of their contents. Since the beds here described occur in a somewhat isolated basin and were separated from the deposits in central Iowa by an extensive land surface, which in Devonian time had perhaps a thousand miles of shore line between the two basins, it would be of interest to know what difference, if any, existed between the faunas of the two regions, and what effect the probable inflow of large quantities of fresh water to this more southern basin had on its contained life.

Although at present unable to correlate the formations on paleontologic grounds, I wish to make a few suggestions as to what correlations are indicated by the lithologic and stratigraphic relations of the deposits. The uppermost horizon of Devonian age in the Mississippi valley is almost invariably a shale, either black or green. In central Iowa it is known as the Hackberry shale; in southern Illinois it is designated as the Green shale; and it is described as occurring in the form of a black shale of very variable thickness through the Ozark hills in Arkansas, westward to and beyond Eureka Springs, where it is correlated with the Eureka shale of southwestern Missouri. I think it very probable that the correlation of the Eureka shale with the Green shale of southern Illinois will be found to be correct; but its relations to the Hackberry shale of Iowa are not so certain.

Lithologically the shaly limestone under the Eureka shale is similar to portions of the Cedar Valley limestone of Iowa. Moreover, it has been subjected at one place in Stone county to the peculiar brecciation and contortion which are so characteristic of the Cedar Valley limestone. This peculiar kind of primary deformation of strata is not common to other formations in the upper Mississippi valley, and it may have been confined chiefly to a given period or epoch of geologic time. In short, I feel reasonably certain that the shaly limestone of my section will be found to be the equivalent of the Cedar Valley limestone of central Iowa.

The crinoidal limestone under it I will not attempt to correlate, as that can best be done by means of its paleontologic relations; and the basal sandstone is undoubtedly only a local development, depending on local conditions, and therefore not to be correlated with any sandstone formation in other parts of the country.

GEOLOGY AT THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

By E. W. Claypole, Akron, Ohio.

The sixty-fifth annual meeting of the British Association for the Advancement of Science began at Ipswich on Wednesday, September 11th. Ipswich is a town of about 60,000 people, situated on the east coast of England. It was the birthplace of cardinal Wolsey and many of the historical incidents and waymarks of the place are connected with him and the events of his life.

The department of geology was well represented and some old familiar faces were present. The president of the section, Mr. Whitaker, delivered an address on the underground waters of Suffolk, tracing their origin and flow in an imaginary subterranean excursion. The rest of the day was spent by many of the sectional members in an excursion to the chalk pits and Eocene beds at Bramford.

On Friday morning sectional work began in earnest with a paper by Prof. Sollas, of Dublin, on the action of pitch in some artificial glaciers of that material, with which he had been experimenting. Placing a mass of pitch in such a position that one end was higher than the other he distributed foreign material of various kinds in the mass and placed obstacles in its path. On examination after an interval of several weeks he found that almost all the planes then formed in the pitch had been bent up on meeting each obstacle and had formed curved lines of flow over it, returning approximately to their former course after having passed it. In this way he proposed to explain the elevation of glacial detritus, such as perched blocks, from lower to higher positions. He quoted in support of his views some photographs taken by Prof. Chamberlin in Greenland in which stones and other material were seen entering the ice at the side of the glacier and riding through it.

His address was illustrated with numerous photographs which were projected upon a screen. A lively discussion followed in which Mr. Godwin Austin, Mr. P. Kendall, Dr. A. Irving, Rev. E. Hill and Profs. Fitzgerald and Claypole took part. Various suggestions and criticisms on the material and the method were made, but the general opinion seemed to be that Prof. Sollas had entered on a valuable and interesting series of experiments and the hope was freely expressed that he would continue them.

Prof. Scott, of Princeton, followed with a paper on the Tertiary lacustrine formations of North America, with lantern illustrations. He briefly but clearly sketched the geological history of these North American Tertiary beds of the West, especially of the Bad Lands,—the Puerco, the Wahsatch, the Bridger, the Uinta, the John Day and the Loup Fork—showing that they were all the deposits of fresh water lakes that occupied different areas in the region during Tertiary time. Each of these he illustrated by some of the remarkable forms of life by which it is characterized.

At the reception by the Ipswich Scientific Society and the Suffolk Institute of Archeology on Thursday evening, Prof. F. W. Petrie exhibited a set of the stone and metal articles found during his recent researches in Egypt. These varied from paleoliths, or instruments of paleolithic type, to flints of the most perfect pattern and finish that can well be conceived. With them were bronze articles of various dates but the oldest were coeval with the exquisite neoliths above mentioned, which are assigned by their discoverer to about 3000 B. C.

The address of the president, Sir Douglas Galton, on Wednesday evening consisted of an extensive review of the progress of the different sciences since the former meeting at Ipswich in 1851, but as geology received only a passing mention it would be irrelevant to dwell further upon it here.

On Saturday interest was divided between the business of the section room, where Prof. O. C. Marsh delighted an appreciative audience with an account of his discoveries and restorations in the great Tertiary deposits of the far West, and an excursion to see the English Pliocene of the county—the red and coralline crags. These beds are very local and are charged with shells in great profusion and frequently in good condi-

tion. Under the guidance of Mr. Whitaker and Mr. Reid pit after pit was visited, and the only regret was that the time allowed only a brief stay in each—enough to tantalize and too little to satisfy. The evidence of a fall in temperature between the coralline crags below and the red crag above, shown by the fauna, was pointed out and an abundance of the crag Mollusca was carried off in bags and boxes. A second visit was made on the following day under the same able leadership to several other quarries in the crags near Sutton, and fresh collections were made.

The French and Belgian visitors to the meeting were heard on Monday morning. M. Dollfüss stated his views on the extent of the sea in western Europe in late Tertiary time and they elicited a lively discussion in which numerous geologists took part. He considered that in Pliocene days a land barrier existed across the English channel and extended northwestward to the Faroe isles and to Greenland, and that the fossils of the English crags were the remnants of the life of the sea on the north of the barrier. Others were disposed to place this barrier farther to the northward. Mr. Van-den-Brock then spoke on the present knowledge which we possess concerning the upper Tertiary of Belgium. After these papers were read and discussed a number of reports of less interesting but very valuable nature were read or taken as read, and the section adjourned to visit the crag and coprolite beds of the vicinity.

The last morning, Tuesday, was occupied with three papers on the exploration which has for some years been proceeding into the deep strata underlying the London basin. They contained the details of several borings and the cores were shown (cut by the diamond drill) out of a hard argillaceous rock whose dip was at a high angle, even up to the vertical, and which showed signs of strong movement and pressure. The age of this stratum was uncertain, opinion hovering between a Carboniferous and a Silurian date, but no doubt was entertained regarding its Paleozoic age, and it was considered as another link in the chain of subterranean investigation that has been for many years in progress. An ingeneous but slow and very laborious method of determining the azimuth of this dip was next given by Mr. Francis, the results of which appeared to be conclusive, but the method itself was too costly

and tedious to allow even a hope of its frequent employment.

Prof. E. W. Claypole followed with two papers, one on the fossil cladodont sharks of Ohio and the other on the fossil placoderms of the same region. Both are of upper Devonian age and the species are too well known to require lengthy mention in this journal.

Two or three reports on geological subjects closed the business of the section, which then adjourned to meet at Liverpool in 1896.

A growing opinion is evident that for the geologists the proper and most instructive place for holding a session is out of doors, in the pits and quarries, and in accordance with this view more and more time is given to excursions to places of geological interest around the town of meeting, the sessions in the room being correspondingly shorter. Besides the trips already mentioned there followed on the Wednesday one to the coprolite beds lying on the London clay, and on the Thursday one to Cromer to see the pre-Glacial forest bed at the foot of the cliffs exposed at low tide only, another to see the collections at Cambridge as well as the other places of interest in that city, and a third to Brandon in Suffolk to see the "flint-knappers" at work. In this last named place the manufacture of flint tools of various kinds has been carried on continuously, or nearly so, from prehistoric to present time. The ground is filled and the surface is strewn with chips and flakes left by the old workers whose modern representations are employed solely in the manufacture of gun-flints.

Ipswich is one of the several English towns of its size,—about 60,000 people,—that possess an excellent museum, the geological department of which includes a very large and well arranged and named collection of the Tertiary fossils of East Anglia, enabling visitors to name their own specimens. The condition and amount of labor that have been spent on the work are honorable alike to the town of Ipswich and to those of its citizens who have devoted their time and study to its geology.

SECTION OF THE EOCENE AT OLD PORT CADDO LANDING, HARRISON COUNTY, TEXAS, WITH NOTES UPON A COLLECTION OF PLANTS FROM THAT LOCALITY, BY F. H. KNOWLTON.*

By T. WAYLAND VAUGHAN, Washington, D. C.

The occurrence of fossil plants at Port Caddo landing and the interesting section seen there have for a good many years been known to the writer. In the summer of 1888 he made a collection of plants, which, still unstudied, are now in the museum of Tulane University at New Orleans. In the summer of 1894, acting under instructions from Mr. Robert T. Hill, the writer had the opportunity of again visiting the locality and making a collection of plants for the U. S. Geological Survey.

The following is a description of the section, from the corner of McCathern's field west to the landing on the south side of the road, beginning at the top:

1. Irregularly stratified sands and clay, about 10 feet. Above this bed in the vicinity red sands occur.

2. Reddish nearly pure quartz sands, sometimes cross-bedded: limonitic geodes and fossil wood abundant. 50 feet.

3. A zone intermediate between 2 and 4, 10 or 15 feet thick. In sands coming just below 2 are water-worn boulders of clay or of laminated clay and sand. The boulders vary in size from that of a pea to that of a man's head. In the lower part of this bed are broken and contorted masses of clay, which may attain a size of several feet in length and a foot in thickness. The stratification planes of the separate masses of clay are set at all angles. There are also interlocking tongues of clay and sand. Below this zone of disturbance a sand bed was seen.

4. Interbedded sands and clays; stratification, so far as seen, regular. The clay is of a bluish color, and the sand grayish. One small lignite seam was observed. Thickness 55 to 60 feet.

5. Poor lignite, 2 feet, frequently replaced by iron ore, iron sandstone or impure limestone. These masses of limestone often appear like huge boulders, but upon close inspection their origin may be discovered easily. They are only replacements

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of the carbonaceous matter of the lignite. From the iron sandstone and limestone masses many excellently preserved fossil plants were collected. From this stratum the plants identified by Prof. Knowlton were obtained.

6. Thinly laminated bluish clay and sand, to water's edge, 13 feet. The section has a slight southerly dip. The measurements were made with an aneroid barometer.

A few yards to the north of the road leading from the corner of McCathern's field to the landing, in a ravine near Bonner's spring, the following is seen:

1. Red clay, 3 or 4 feet.
2. Gray, blue or whitish sand, with some clay, containing water-worn boulders of laminated sand and clay, 15 feet. These boulders upon being split reveal good impressions of leaves.
3. Blue clay, a few inches.
4. Lignite, 4 feet.

Two of this section represents 3 of the first section.

The interesting part of the above section, aside from the plants, is the interpretation of the phenomena seen in 3 of the first section and 2 of the second. There has certainly been some erosion. Is it only a local unconformity, or do the sands with the boulders, etc., at the base represent what Mr. McGee has called the Columbian stage? After studying all that he could find at Port Caddo the writer was not able to reach a positive conclusion, but from the sands apparently passing below other stratified clays, of Eocene type, he is inclined to believe that we have an instance of local unconformity in the Eocene. Until the stratigraphy can be studied in more detail a positive opinion cannot be expressed.

Near Jonesville, Texas, rounded boulders of lignite have been found by Dr. Otto Lerch* and the author.

Around Port Caddo the superficial sands give the character to the topography of the country. These sands erode very easily and steep ridges with round lateral lobes, separated by deep gulches, are formed. The vegetation is pine. Often the sands of the surface are indurated by ferruginous cement into iron sandstone of a good quality. This sandstone constitutes a resisting stratum that caps the hills, below it precipitous slopes and deep gulches being developed.

*Report Geol. Hills. N. La., pt. II, p. 87.

In this vicinity lignite is extremely abundant. We know these beds are Eocene, but to what stage of that series to refer them is a difficult question. The opinion was expressed by the writer in a recent article that they were of Lignitic age.* Unfortunately the determination of the age of our Eocene deposits depends entirely upon the fossil animal remains, because no systematic study has been made of the floras. Divisions founded upon mere lithologic characters are insufficient, as lignitic strata are found in every division of the Eocene. At present the determination of the age of any part of the lignitiferous Eocene of the Gulf states depends entirely upon a minute knowledge of the stratigraphy of the surrounding regions in which marine fossils have been found. On a blue-print map which has recently been distributed by W. Kennedy, entitled "Map showing Areal Distribution of the Eocene Tertiary in East Texas, Compiled from Geological Surveys," it appears that most of the beds devoid of marine fossils and consisting of lignitic strata have been designated as of "Lignitic" age. The present writer doubts the correctness of this.

The reason for considering the Port Caddo section of Lignitic age is because Mr. Harris in his report on the geology of southern Arkansas has indicated the Lignitic-Claiborne as running to the headwaters of the lakes developed along the Red river. His work was based upon both careful paleontologic work and field study. The streams in northwestern Louisiana and the adjoining part of Texas, i. e., Red river, Cypress bayou and the other streams of that type, have cut far down into the formations upon which their courses lie. The elevation at Jefferson, Texas, is 231 feet; at Shreveport, Louisiana, it is 185 feet. It would seem most probable that into this low-lying country along these streams where there had been so much erosion that we would find an extension of the Lignitic from Arkansas. Capping the highlands surrounding this eroded area, to the east, south and west we have remains of the marine (lower Claiborne) beds. In the vicinity of Daingerfield, which is northwest of Port Caddo, at an elevation of 400 feet, there is an area of the marine beds.† At

*Amer. Geol., vol. xv, p. 209, April, 1895.

†Kennedy's map.

Marshall, Texas, which has an altitude of 375 feet (from T. & P. R'y elevations), an area of the marine beds occurs. The beds at Port Caddo, at least in their lower portion, are lithologically like those called "Lignitic." From these data it would seem that there is little doubt regarding the correctness of the age that is suggested, for the lower part of this section.

The Eocene fossil plants offer a most interesting field for study, as probably they will ultimately aid us in the correlation of our great southern plant-bearing beds with the plant-bearing beds of the west. Prof. Knowlton's accompanying report shows this, and Messrs. Penrose* and Hill† have made important remarks bearing on the same problem. From Louisiana Lesquereux‡ has identified fossil plants collected at two localities.

In the following table I have placed alongside each other the lists from Lesquereux's paper and from Prof. Knowlton's:

Port Caddo Landing, Tex.	Campbell's Quarry, Cross Lake, La.	2 miles N. of Mansfield, La.
Salix tabellaris? Lx.	*Sapindus angustifolius* Lx.	*Magnolia laurifolia* Lx.
Magnolia laurifolia? Lx.	*S. caudatus* Lx.	*Ficus spectabilis* Lx.
M. ovalis Lx.	*S. coriaceus* Lx.	*Aralia* fragment.
Juglans appressa Lx.	*Magnolia laurifolia* Lx.	*Platanus guillemæ* Göpp.
Ficus schimperi Lx.	*Laurus socialis* Lx.	
Ficus, n. sp.	*L. utahensis* Lx.	
Ficus, n. sp.	*Rhamnus cleburni* Lx.	
Cinnamonum affine Lx.	*R. eridani* Ung.	
C. mississippiense Lx.	*Carya antiqua?* Ny.	
Laurus or *Litsæa*, n. sp.	*Quercus angustiloba* Al. Br.	
Juglans? n. sp.	*Ficus goldiana* Lx.	
	F. goldiana Lx., var. *spectabilis* Lx.	
	Phragmites oeningensis Lx.	

It is quite probable that the bed from which I obtained the specimens at Port Caddo landing and that from which Johnson obtained those sent by him to Lesquereux from Cross lake

*1st Ann. Rep. Geol. Survey Texas, p. 21, 1890.

†Neozoic Geol. of Southwestern Ark.: Ark. Geol. Survey, pp. 62-65, 1888.

‡Proc. U. S. Nat. Mus., vol. xi, for 1888, pp. 24-25, published 1889.

are of the same age. I have maintained the opinion that the Mansfield group, from which the specimens two miles north of Mansfield come, is of lower Claiborne age.

The object of this brief paper is: 1, to call attention to the phenomena seen in bed No. 3 of the first section and in bed No. 2 of the second section; 2, to emphasize our lack of data for a thoroughly satisfactory correlation of the plant bearing beds of the Eocene of the Gulf states; 3, to call attention to the excellently preserved fossil plants found at Old Port Caddo landing.

The following is Prof. Knowlton's report:

Report on a small Collection of Fossil Plants from Old Port Caddo Landing, on Little Cypress Bayou, Harrison County, Texas, made by Mr. T. Wayland Vaughan.

A somewhat hasty study of this material gives the following results:

Salix tabellaris? Lx. A single rather doubtful leaf.

Magnolia laurifolia? Lx. A fragmentary leaf that seems to belong to this species.

Magnolia ovalis Lx.

Juglans appressa Lx.

Ficus schimperi Lx.

Ficus, n. sp. A large leaf four and one half inches wide with wedge-shaped base.

Ficus, n. sp. Also a large leaf, but with a broad rounded base.

Cinnamomum affine Lx. A number of leaves of this species, all well determined.

Cinnamomum mississippiense Lx. This is represented by only one leaf. This species should in all probability be referred to *C. affine*.

Laurus or *Litsæa*, n. sp. A fine leaf and well preserved. It resembles a number of described forms, but differs from all in well marked particulars.

Juglans? n. sp. A number of doubtful fruits are possibly of this genus. They are hardly well enough preserved to admit of characterization.

Fragments.

This material appears to belong to the so-called eo-lignitic. Of the seven species determined specifically four or five have

been found outside of this formation. The others have been detected in a number of places, notable in the Denver beds of Colorado. They are too few in number, however, to base very definite conclusions on.

Only one short paper has ever been prepared on the flora of this eo-lignitic group, and while there is much material in hand there is at present little that may serve as a basis of comparison between it and other localities. Most of the species are peculiar to these beds, but a few have been found in the Denver (upper Laramie) beds of Colorado. It is altogether probable that when this eo-lignitic flora comes to be thoroughly worked up it will be found to correspond very closely with the Denver beds. Until more systematic work can be done it is manifestly impossible to generalize further.

Very respectfully,

F. H. KNOWLTON, Asst. Paleontologist.

EDITORIAL COMMENT.

PROFESSOR HEIM'S LETTER.

In answer to the criticism by Prof. Heim of my statement of the prize essay incident in the sixth session of the International Geological Congress, I refer for corroboration of every detail but one as printed in the AMERICAN GEOLOGIST (vol. XIV, no. 4) to Prof. Capellini, who I feel sure will confirm my notes taken at the time the statements were made. The one exception is the amount of the prize, which is not distinctly stated in my notes and for which I doubtless trusted to my memory.

Prof. Heim is in error in stating that in returning the manuscript to Prof. Capellini he has "done as it" (i. e. the Congress) "decided." The Congress refused to meddle with the question.

I am not familiar with the use of the German language which designates the seventy-ninth recurrence of a natal day as the eightieth birthday, and if this be the custom in German Switzerland I own that I should have made an error had I attempted to designate such an anniversary. But my ignorance, which I confess and deplore, has nothing to do with the case since I nowhere hazarded an assertion in the sentence

which is the basis of my learned critic's stricture. After stating that Prof. Heim had extended the good wishes of the Congress to Geheimrath Beyrich on the occasion of his eightieth birthday, I added, "The good feeling was very hearty and spontaneous, but the recipient seemed somewhat embarrassed by it; perhaps for the reason, which he explained to your correspondent, that he does not attain his eightieth birthday till next year."

Unless, therefore, I mistook the intent of Geheimrath Beyrich, it was he not I who noted the discrepancy, and it was he who must have been unfamiliar with the use of the German language in this particular.

As to the "numerous misunderstandings" in my letter of a year ago, which my distinguished reviewer will not mention because they do not affect him, I should be glad to hear from those they do affect and I promise to promptly withdraw if I cannot justify these "misunderstandings."

PERSIFOR FRAZER.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Fourteenth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1892-'93. By J. W. POWELL, Director. (Part I: Report of the Director, 321 pages, with map (plate I) showing progress of the topographic survey, 1893: Part II: Accompanying Papers, XX and 597 pages, with plates II-LXXIV, and 75 figures in the text, 1894.) During the year of this report the appropriations for the survey were much diminished, requiring important changes in the plans of work and reduction in the number of geologists and assistants employed. Topographic work received $249,200: strictly geologic work, $63,700; paleontologic work, $14,000: chemical work, $8,000: preparation of illustrations, $5,000: the report on mineral resources, $10,000; purchase of books, etc., $2,000: the engraving of geologic maps, $10,000; and rent, $4,200. The topographic surveys of the year were platted on 91 atlas sheets, bringing the total number of surveyed sheets up to 785, representing 573,000 square miles, or about a sixth part of the entire national domain, excepting Alaska.

In Part I the Director's report fills 165 pages, and the remainder of this volume comprises the twenty-eight administrative reports of chiefs of divisions and heads of independent parties, besides the abstracts of disbursements for the survey, which last occupy 40 pages.

Part II contains the geological map of the United States by W J McGEE, of which notices have been given in previous numbers of the

AMERICAN GEOLOGIST (vol XVI, pp. 61, 113, July and August, 1895); a paper entitled "The Potable Waters of eastern United States," also by Mr. McGEE, in 47 pages, with five figures; "Natural Mineral Waters of the United States," by A. C. PEALE, in pages 49-88, with two maps; "Results of Stream Measurements," by F. H. NEWELL, in pages 89-155, with two plates, and 19 figures; "The Laccolite Mountain Groups of Colorado, Utah and Arizona," by WHITMAN CROSS, in pages 157-241, with ten plates and 19 figures; "The Gold-Silver Veins of Ophir, California," by WALDEMAR LINDGREN, in pages 243-284, with two plates; "Geology of the Catoctin Belt" [beginning in the south edge of Pennsylvania, extending across Maryland and into Virginia], by ARTHUR KEITH, in pages 285-395, with 21 plates and one figure; "Tertiary Revolution in the Topography of the Pacific Coast," by J. S. DILLER, in pages 397-434, with eight plates and four figures; "The Rocks of the Sierra Nevada," by H. W. TURNER, in pages 435-495, with twelve plates and three figures (a paper which was summarized by the author in the AMERICAN GEOLOGIST for April and May, 1894); "Pre-Cambrian igneous rocks of the Unkar terrane, Grand Canyon of the Colorado, Arizona," by CHARLES D. WALCOTT, with notes on the "Petrographical Character of the Lavas," by JOSEPH PAXSON IDDINGS, in pages 497-524, with six plates and two figures; "On the Structure of the Ridge between the Taconic and Green Mountain Ranges in Vermont," by T. NELSON DALE, in pages 525-549, with five plates and eleven figures; "The Structure of Monument Mountain in Great Barrington, Massachusetts," also by Mr. DALE, in pages 551-565, with two plates and eight figures, and "The Potomac and Roaring Creek Coal Fields in West Virginia," by JOSEPH D. WEEKS, in pages 567-590, with two maps and three figures.

Presenting so many reports of important special investigations, this volume is one of the most valuable in its series. The longest of these reports, by Mr. Keith, gives the following approximate ratios of the duration of Tertiary and Quaternary time, derived from comparisons of their relative amounts of denudation in the district comprising the Catoctin mountain, namely, the Tertiary era, regarded as extending to the end of the Lafayette period, 134; the early part of the Pleistocene period, 1; its later part, 5/6; and the Recent period, a small fraction. If the Ice age and subsequent time have included about 60,000 years. Tertiary time was, according to this estimate, about 4,000,000 years, and the geologic record from the dawn of life on the earth would be, according to Dana's ratios for the great eras, some sixty to a hundred million years. W. C.

Republication of Descriptions of Fossils from the Hall Collection in the American Museum of Natural History, from the Report of Progress for 1861 of the Geological Survey of Wisconsin, by James Hall, with illustrations from the original type specimens not heretofore figured. By R. P. WHITFIELD. (Memoirs Amer. Mus. Nat. Hist., vol. I, pt. 2, roy. 4to, pp. 39-74, pls. iv-xii, 1895.) Professor Whitfield has done a genuine service to American paleontology in the illustration of these hitherto almost unrecognizable Silurian species published nearly thirty-five years ago. Paleontologists who have had occasion to study,

of late years, fossils of this formation from the state of Wisconsin or its vicinity have been at a great disadvantage from the difficulty in getting clear conceptions of important species from their brief preliminary descriptions. This embarrassment has especially been felt by the workers who have recently been engaged in the preparation of the volumes on the paleontology of Minnesota, and probably they will lament most loudly the late appearance of these illustrations while rejoicing that the unfulfilled promise of the state of Wisconsin to Prof. Hall has been so well redeemed by Mr. Whitfield.

The species considered are all of Trenton age with one exception (*Melocrinus nodosus* from Devonian drift) and the generic determinations are wholly those of Hall, except where the author had himself introduced a generic term, *Callihamnopsis*, based upon one of these species, *Oldhamia fruticosa* Hall. Mr. E. O. Ulrich's generic designations for the Lamellibranchiata are not recognized and a considerable number of that writer's species described in his report for the paleontology of Minnesota are here included in the synonymic lists. The work maintains the magnificent proportions established by the first number of these memoirs, and the plates (with the exception of the first, which is a photo-engraving representing certain algous fossils, a part of which the author had described in another paper) are exquisite examples of lithographic drawing and printing. J. M. C.

Ammoniten-Brut mit Aptychen in der Wohnkammer von Oppelia steraspis Oppel sp. By R. MICHAEL. (Zeitschr. der deutsch. geolog. Gesellsch., vol. XLVI, pp. 697-702, pl. liv, 1895.) The author describes a fossil of notable interest to the paleontologist. In the body-chamber of an ammonite, whose aperature is closed by an aptychus in nearly its normal position, is a cluster of some sixty minute aptychi with remnants of diminutive shells. The specimen suggests some important facts which are duly emphasized by the author; that the brood of the ammonites after becoming free from the ovisac are carried about for a time in some part of the habitation-chamber; that the aptychus or operculum is developed very early in the life of the animal and hence its function is of serious importance to the organism. The specimen is from Solenhofen. J. M. C.

Revision of the Fauna of the Guelph Formation of Ontario, with descriptions of a few new species, and

Systematic list, with references, of the Fossils of the Hudson River or Cincinnati Formation at Stony Mountain, Manitoba. By J. F. WHITEAVES. (Geological Survey of Canada, Palæozoic Fossils vol. 3, pt. 2, pp. 45-128, pls. 9-15. Sept., 1895.) Since the first description of fifteen species of fossils from the Guelph by Hall in 1852, and twenty-one additional species by Billings in 1862 and 1865, further contributions to the fauna have been quite desultory. The dolomitic character of the rock and the condition of preservation of the fossils are such that fine cabinet specimens are rarely obtained and their study is somewhat difficult. "Of late years particular attention has been given to the col-

lecting of natural moulds of the exterior of shells of Gasteropoda, etc., from this formation, as it has been found that gutta percha impressions of such moulds often give much more information about the exact shape and surface markings of the shell than can be derived from mere casts of the interior." The further light thrown upon the Upper Silurian Gasteropoda by Lindström's researches in Gotland has made it desirable and practicable to review all the species thus far known from the Guelph formation of Ontario. The author now brings together about one hundred and thirty species from this horizon, of which six are new. The entire number is distributed as follows: Corals 12 species, Hydromedusæ 6, Brachiopoda 25, Pelecypoda 10, Gasteropoda 54, Cephalopoda 15, and Crustacea 7. The absence of echinoderms and the abundance of gasteropods are conspicuous features. Among the latter, *Pleurotomaria* and *Murchisonia* are the most diversified types. The trimerellids are the dominant brachiopods and give a peculiar aspect to the fauna.

In the second paper an annotated list of nearly sixty species is given from the only known locality of the Hudson River group in Manitoba.

C. E. B.

Fauna fosil de la Sierra de Catorce San Luis Potosi, y JOSE G. AGUILERA. (Comision Geologica de México, Antonio del Castillo, Director, Boletin Num. 1, 55 pp., 24 pls., 1895.) The first memoir of a new series of publications by the Mexican government is a welcome contribution to our knowledge of North American Mesozoic geology. In attempting to establish the existence of the Jurassic as a well defined formation in that part of the continent, the evidence of recently discovered fossils is relied upon. Most of the species considered are described as new, the many and minute comparisons which are made with allied forms in other parts of the world is an admirable feature in aiding paleontologists to better understand the true character of the fauna studied. The fossils are for the most part cephalopods, though the brachiopods and lamellibranchs are comparatively well represented. Most of the material upon which the investigations are based is evidently in a good state of preservation, but it is rather unfortunate that better illustrations were not prepared for some of the forms. With the methods employed in the reproduction of the illustrations the details of the highest specific and generic importance are largely obscured and in some cases entirely obliterated.

C. R. K.

Bureau of Mines of Ontario, Fourth Report, 1894. ARCHIBALD BLUE, Director. (8vo, pp. vi, 261; maps and illustrations of the Rainy River district; Toronto, 1895.) The contents of this volume are: 1. A general discussion (pp. 7-34) of the condition of the mining industry of Ontario during the year, with particular reference to certain branches in process of development at present. 2. A chapter (pp. 35-100) on "Gold in Ontario," with particular description of the Rainy Lake gold region, by Dr. A. P. Coleman. 3. A compiled account (pp. 101-138) by Mr. T. W. Gibson of the "Hinterland of Ontario," by which is meant the region lying be-

tween lakes Huron and Superior on the south and Albany river and James bay on the north. 4. A chapter (pp. 139-165) on calcium carbide and acetylene gas, consisting of extracts from articles by Vivian B. Lewes, T. L. Willson and J. Suckert. 5. Account of the steps to be taken to procure the assistance of the government in making diamond drill explorations. 6. A chapter (pp. 177-198) on "Nickel and its Uses." 7. Mining accidents (pp. 199-215). 8. Summer mining schools (pp. 216-222). 9. Fifth Report of the Inspector of Mines (pp. 223-253).

The principal article and the one which represents the largest amount of original geological work is the one by Dr. Coleman on gold in Ontario. The description of the rocks of the Rainy Lake region is based on Lawson's classification, and in other respects agrees with the main facts as set forth in the twenty-third Annual Report of the Geological and Natural History Survey of Minnesota. The views of Winchell and Grant as to the relative ages of the granite and gabbro of Shoal and Bad Vermilion lakes are held by Dr. Coleman to be more probable than those expressed by Dr. Lawson.

The general conclusion reached is rather conservative as to the prospects for gold mining, although some of the samples assayed gave very good results and portions of the district, especially the Seine River region, are considered quite promising.

A few errors of fact have crept into this report from a lack of perfect familiarity with the region. Thus it may be pointed out that the waters of Rainy lake are usually not turbid nor brownish, but clear and colorless; that trout frequent its waters, bass are not uncommon in surrounding lakes and the drainage is not into Red river; that the cost of milling at the Little American mine is not given in the Minnesota report as $7 per ton. It would appear that the preference of the term "bedded" rather than "segregated" as applied to the veins in the green schist is not well founded, for as the writer himself states, the veins have probably had an origin similar to that of the fissure veins and therefore are not of the nature of interstratified deposits or beds, but rather formed by the action of segregation in its broadest sense. The report as a whole gives a good idea of the geology and developments of this new district and will be useful to all interested in the region.

The Ontario Bureau of Mines is doing a good work and doing it well. Many of our states could do worse than to copy the example of Ontario and establish a mining department which should combine under one head and in one report the branches of mine inspection and the advertisement of the resources and industries of the state through competent reports. H. V. W.

Scientific Results of the New Siberian Islands Expedition in the years 1885 and 1886, Part III: The Fossil Ice Strata and their Relations to the Mammoth Remains. By Baron EDUARD V. TOLL. (Memoirs of the Imperial Academy of Sciences of St. Petersburg, seventh series, vol. XLII, no. 13, pp. vii, 1-86, with 7 plates and 17 figures in the text; 1895.) Underground strata of ice are found in many localities of the tundras from the Yenisei river eastward about 2,500 miles to Bering strait and

sea, and to Eschscholtz bay and the Kowak and Yukon rivers in Alaska. These fossil accumulations of ice, covered by a thin soil in which occur shells of Cyclas, Valvata, etc., wood of alder, willow and dwarf birch, and abundant bones and ivory tusks of the mammoth are especially extensive in the New Siberia islands. The great Lyakhoff island, having an area of about 2,000 square kilometers or 700 square miles, is wholly thus underlain by ice, excepting four granite peaks, and the fossil ice has a similar development in the more northern islands of this group.

Baron Toll ascribes the thin overlying clay and sand to the action of wind and water as eolian and lacustrine deposits: but it seems worthy of inquiry whether in the New Siberia islands and many other places they may not instead be derived mostly from englacial drift which became superglacial by ablation of formerly higher strata of ice, as on the borders of the Malaspina ice-sheet south of Mt. St. Elias. In some localities, as along valleys and avenues of drainage, Baron Toll considers the underground ice as remnants of frozen river waters during a former epoch of greater severity of cold, and there the overlying soil may well be of fluviatile origin; but on these islands he finds, by the granular structure of the ice, that it is derived from snowfall, being a remnant of a previous ice-sheet. Several views show marginal ice-cliffs on the Lyakhoff island having a vertical hight of about 60 feet, capped by two or three feet of soil. Likewise the description given by Dall for the ice-cliffs of Eschscholtz bay in Alaska, comparing the texture of the ice to compacted hail, proves, as Baron Toll remarks and as was noted in the last April Am. Geologist (vol. xv. p. 258), that the ice there also is a remnant of an ice-sheet. In these places probably the overlying soil was englacial drift in a formerly much thicker sheet of land ice, similar to the Pleistocene ice-sheets of North America and Europe, though of smaller extent.

The mammoth remains are never in the ice, but in frozen mud and sand beds distinct from the fossil ice masses and often overlying them. During a time closely following the Glacial period, a warmer climate than that of the present day prevailed in Siberia and Alaska, enabling shrubs to grow two hundred miles north of their present limits, while herds of the mammoth and woolly rhinoceros, both of which have since become extinct, ranged north to the Arctic sea. The mild postglacial climate may have been due to a depression of the area about Bering strait, permitting a strong warm current from the Pacific to pass north through this strait. Its width now is 28 miles, with a nearly uniform depth of 24 to 28 fathoms, and the present currents vary in direction with stages of the tides. A moderate subsidence, which is indicated by the raised beaches of this region, similar to the subsidence of the drift-covered parts of North America and Europe during the Late Glacial or Champlain epoch, and probably contemporaneous with that epoch, seems therefore, in the opinion of the reviewer, to be the best explanation of the Siberian and Alaskan fossil remains of ice-sheets and of extinct mammals. When the ensuing re-elevation, shutting away the

warm marine current, brought again an arctic climate, the melting of the thick sheets of land ice, protected by their superglacial drift, nearly ceased; and the mammoth and rhinoceros perished with cold and hunger, although these species had endured in migratory herds the more severe Glacial period, which there apparently was characterized by the accumulation of numerous local ice-sheets, occupying hundreds or thousands of square miles. Instead of merely ordinary winter storms and deep snowdrifts, to which Mr. Charles Davidson has attributed the extinction of the mammoth and the origin of the underground ice (Q. J. G. S., vol. 50, pp. 472-486, Aug., 1894), very important secular climatic changes, with epeirogenic movements, seem to have occurred in a series approximately parallel with those of the Glacial and Recent periods on the opposite sides of the North Atlantic ocean. W. U.

Further Observations upon the Occurrence of Diamonds in Meteorites. By O. W. HUNTINGTON. (Proceedings, Am. Acad. of Arts and Sciences, new series, vol. XXI, 1894, pp. 204-211, with two plates.) The investigation here noted was made with fragments of the Cañon Diablo or Coon Butte meteoric iron, which was first described by Dr. A. E. Foote in the Proceedings of the American Association for 1891 (vol. XL, pp. 279-283), and to which also attention has been directed, with careful instrumental surveys, by Mr. G. K. Gilbert, as reported in the AM. GEOLOGIST (vol. XIII, p. 115, Feb., 1894.) Many pounds of this iron were dissolved by the author, who thus obtained from it enough diamond dust to use at the Columbian Exposition for cutting and polishing rough diamonds. Only a few perfect crystals were found, these being of minute size, as about a hundredth of an inch in diameter. These observations seem well accordant with the theory of the late Prof. H. Carvill Lewis concerning the origin of diamonds, and he had actually predicted in 1886 that diamonds would be discovered in meteorites. W. U.

The Erosive Action of Ice. By G. E. CULVER. (Trans., Wisconsin Acad. of Sciences, Arts, and Letters, vol. x, pp. 339-366, April, 1895.) The opinions of many European and American geologists are here reviewed, and the author records his own observations of striated boulder pavements, where deposits of till have suffered glacial erosion near Big Stone City, South Dakota, and on the Big fork of Rainy river in northern Minnesota. He concludes that the efficiency of ice to excavate rock basins has been greatly overestimated. Indeed he thinks that after the many years of discussion of this question, "not a single case of a lake basin which can be proven to have been made by ice action has been discovered." W. U.

The Duration of Niagara Falls and the History of the Great Lakes. By J. W. SPENCER. (Pages 126, with five plates and 27 figures in the text, forming the second part of the Eleventh Annual Report of the Commissioners of the State Reservation at Niagara, for the year 1894, Albany, 1895; also published, at the price of $1, in the Humboldt Library series.) Nine papers relating to the Laurentian lakes and Niagara falls, published by Prof. Spencer within the past six years in the

Bulletin of the Geological Society of America, the Quarterly Journal of the Geological Society of London, and the American Journal of Science are here collected to give in one publication the results of his extensive explorations and studies in this district. With these he might well have included also his earlier paper on the "Discovery of the Preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario, with notes on the Origin of our Lower Great Lakes," from the Proceedings of the American Philosophical Society (vol. XIX, pp. 300-337, 1881). The chief outlines of the author's work, as given in these papers, have also been recently stated by him in the AMERICAN GEOLOGIST (vol. XIV, pp. 289-301, Nov., 1894). His estimate of 32,000 years as the past duration of the Niagara river and falls seems, however, to the present reviewer less in accordance with the results of many investigations bearing on the duration of the Ice age and of the Postglacial period, than the 7,000 years which Gilbert estimated, with some considerations tending to increase and others to reduce the estimate, in his American Association paper in 1886. This question, and that of the Nipissing outlet from lake Algonquin, on which Prof. Spencer bases the greater part of his large estimate, have been considered in the AMERICAN GEOLOGIST (vol. XIV, pp. 62-65, July, 1894), with the conclusion that the volume of the Niagara river has been nearly as now through all its history. W. U.

Critical Periods in the History of the Earth. By JOSEPH LECONTE. (University of California, Bulletin of the Department of Geology, vol. I, pp. 313-336, August, 1895.) This paper is a more full statement of the conclusions presented by the author two years ago in the World's Congress of Geologists at the Columbian Exposition, on the question, "Are there any natural divisions of the geological record which are of world-wide extent?" An outline of that address was given in the AM. GEOLOGIST for October, 1893 (vol. XII, p. 272). Critical periods, having exceptionally rapid evolution of new species of plants and animals, so that they mark the limits of the great geologic eras, are shown to be produced by exceptionally great changes in physical geography, permitting migrations with adaptation to new environment, and by climatic changes, which compel migrations along north and south courses. The more rapid rate of evolution gives rise to higher dominant classes, and the great changes brought by the dominion of man over the lower animals and plants have led the author to name the latest and present grand division of geologic time the Psychozoic era. He would terminate Quaternary time at the end of the Glacial period, and would unite the Tertiary and Quaternary divisions of time as together constituting the Cenozoic era. By the epeirogenic movements inaugurating the Glacial period, North America and northern Europe were "certainly raised at least three thousand feet and probably much more;" and at nearly the same time the Sierra Nevada, Wahsatch and St. Elias ranges were greatly uplifted by block-tilting.

As the Glacial period marked the limit of the Cenozoic era, so the Laramie period, with still grander epeirogenic and orogenic changes, the latter taking place especially along the Cordilleran or Rocky Moun-

tain belt, ended the Mesozoic era: the Permian period, with the Appalachian revolution, terminated Paleozoic time; and the greatest of all the critical periods or revolutions divided the Archean and Algonkian ages from the Cambrian.

Although the records of critical periods on account of the great geographic changes and unconformity of the rock series are principally lost, these periods are believed to have been of long duration. Their changes of organic forms were not simultaneous everywhere, but rather were propogated from place to place by waves of migration, which may have reached far beyond the limits of the physical changes. W. U.

Ueber einige Fischreste des norddeutschen und böhmischen Devons. By A. von Roenen. (Abhandl. der Königl. Gesellsch. der Wissensch. zu Göttingen, vol. 40, pp. 1-37, pls. i-v, 1895.) In continuation of his investigation of the Devonian fishes of Germany the author here publishes accounts of the following species: From the upper Devonian, *Ctenacanthus ? erectus*, nov., *Coccosteus inflatus*, v. k., *Brachydirus carinatus*, v. k., *Aspidicthys ingens*, v. k., *Anomalicthys scaber*, v. k., *Phatyaspis tenuis*, nov. gen. et sp., *Holoptychius kayseri*, nov., *Glyptolepis traquairi*, nov., *Rhizodopsis dispersa*, nov.; from the middle Devonian, *Dinicthys efeliensis* Kayser, *Macropetalicthys agassizi* v. Meyer., *Osteolepis holzapfeli*, nov.; from the lower Devonian, *Macropetalicthys prümiensis* Kays., *Holopetalicthys novaki*, nov. (stage F. Bohemia). J. M. C.

Sur une Faune du sommet de la serié rhénane, a Pepinster, Goé et Tilff. By E. Kayser. (Ann. de la Soc. géol. de Belgique, vol. xxii, pp. 177-216, pls. i-iv, 1895.) The author describes a recently discovered Belgian fauna which he refers to the upper part of the lower Devonian. The assemblage of species is especially notable for the considerable number of lamellibranchiates belonging to species and genera peculiarly American. "The American aspect which this fauna bears is one of the most interesting results of this work and is the foundation of a remarkable distinction between the lower Devonian of Belgium and that of the Rhine in which American analogies seem to be wanting. Belgium is not unique in this respect. This American expression of the lower Devonian fauna reappears at the same horizon in the northwest of France. * * * The relations existing, during the lower Devonian, between the basin of Belgium and the north of France and that of North America are perpetuated to the close of the Devonian period as shown by the existence of American species of Aviculidæ mentioned by Gosselet and Frech in the upper Devonian of Belgium, although these species are absent on the Rhine." J. M. C.

The Stone Industry in 1894. By William C. Day. (16th Ann. Rept. U. S. Geol. Survey, pt. IV, 83 pp., 2 pls. 4-27, 1895.) It is with pleasure that we note the appearance of this portion of the results of the work on the mineral resources for the year 1894 before the end of 1895. (Part IV of the 16th Ann. Rept. of the Survey is entitled "Mineral Resources of the United States, calendar year 1894.") In describing the

stone industries the different kinds of stone noted are granite, marble, slate, sandstone, limestone and bluestone. Granite includes all quarried igneous rocks, gneisses and crystalline schists. The total production of stone in the United States for 1894 was valued at over $37,000,000 —a gain of about $3,500,000 over the total production for the previous year. A large number of statistical tables accompany the paper, and some information is given concerning the methods of quarrying and dressing the various stones. A locally interesting feature is a brief description of the status of each kind of stone industry in each state.

U. S. G.

Mineral Products of the United States, calendar years 1885 to 1894. By DAVID T. DAY, Chief of Division of Mineral Resources. (U. S. Geol. Survey; Washington, June 8, 1895.) On a large sheet, about 24 by 30 inches, is presented a tabulated statement of the quantity and value of each mineral substance produced in the United States during the last ten years. The value of the total product decreased decidedly both in 1893 and 1894. The total valuation in the latter year was $527,655,562, which is lower than the total valuation of any year since 1887. The greatest total production was in '92 when the valuation was $648,616,954.

U. S. G.

Opinions Concerning the Age of the Sioux Quartzite. [Abstract.] By CHARLES ROLLIN KEYES. (Proc. Iowa Acad. Sci., 1894, vol. 2, pp. 218-222; 1895.) A resumé is given of the opinions of various authors regarding this quartzite which was called "Sioux quartzite" first in 1870 by Dr. C. A. White. It is of interest to note that Dr. F. V. Hayden seemed inclined to the view that the age of this rock was post-Carboniferous and perhaps Cretaceous. The general consensus of recent opinion regarding this quartzite is that it is of pre-Cambrian age; it is placed in the middle division (Upper Huronion) of the Algonkian in recent publications of the United States Geological Survey. Prof. N. H. Winchell has been about the only one lately to entertain a different opinion and he has in several papers uniformly placed it in the Cambrian. In the present paper the author states that the fossils (a brachiopod and a trilobite) found in the Sioux quartzite are generally regarded as not of organic origin. The reviewer does not understand that this is the case with the brachiopod (*Lingula calumet*,) which seems to be generally acknowledged as a fossil. He understands that both Messrs. Walcott and Van Hise are agreed as to its organic origin; the latter writes: "In the Sioux quartzites one generally accepted fossil has been found by N. H. Winchell." (Bull. 86, U. S. Geol. Survey, p. 194.)

Dr. Keyes entertains some doubt as to the pre-Cambrian age of this quartzite. In his closing paragraph, after a personal examination of many of the principal outcrops, he states "that it must be confessed that notwithstanding strong preconceived notions regarding the great antiquity of the Sioux rock, faith in its very old age was considerably shaken * * * * * Regarding the age of the Sioux formation, it may be said that while it should be considered as pre-Cambrian in age—

until indisputable evidence is produced to the contrary—there exists now a certain element of doubt concerning the accuracy of this view."

U. S. G.

Ueber postarchæischen Granit von Sulitelma in Norwegen und über das Vorkommen von s. g. Corrosionquarz in Gneisen und Graniten. By OTTO NORDENSKJOLD. (Bull. of the Geol. Dept. of the Univ. of Upsala, vol. II, pt. 1. no. 3, pp. 118-128, 1895.) The district of Sulitelma, in 68° N. Lat., and on the border between Sweden and Norway, has been the subject of careful research by a number of geologists on account of the occurrence there of rich copper ores. Occupied with similar research, the author had opportunity to study a granitic rock, interesting on account of its occurrence in the form of a laccolitic lens included between the mica slates, having a length of more than five kilometers and a breadth of at least 1,200 meters. The age of the schists is not known with certainty, but must be considered as post-Archean and pre-Devonian. Though the granite (as well "im Hangenden als im Liegenden") very rarely and in small degree traverses the schists, it must be considered as younger and not cotemporary with them. Now it is interesting that, while all Swedish granites of post-Archean age when occurring in undisturbed positions are very well characterized, this rock - a porphyritic mica-granite, more or less gneissoid—much resembles the old Archean granites. The same appears to be the case also in other parts of the mountain districts in Scandinavia where granites occur in the same position. The author concludes that they have all been intruded simultaneously with the folding of the rocks and the forming of the mountains, and have therefore obtained their layer-like position and their aspect of greater age.

An interesting feature in all these rocks is the great development of the structure, described by Fouqué and Michel Lévy under the name "quartz de corrosion," consisting of complex aggregates of quartz and feldspar, similar to the granophyric structure but distinctly different as the included quartz individuals are always limited by bent and curved lines. The author has studied this structure in a number of rocks and has found it very common in gneisses, but rather rare in eruptive rocks where it occurs only in rocks altered by dynamic action, it therefore is probable that it has always been formed in connection with dynamic metamorphism. The author has since seen in Paris, in the collection of Prof. A. Lacroix, a granitic rock of post-Carboniferous age from the Pyrenees, which, having taken part in the forming of mountains, is wonderfully like the rock from Sulitelma and shows the same structure. It is of great importance to distinguish the structure here mentioned, occurring in gneisses and altered granites, from the granophyric structure found probably only in igneous rocks.

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Science, Oct. 4, 1895. A new Jurassic plesiosaur from Wyoming, W. C. Knight.

Science, Oct. 11, 1895. Some notes on Darlington (S. C.) "bays," L. C. Glenn.

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American Naturalist, Oct., 1895. The first fauna of the earth, J. F. James.

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IV. Excerpts and Individual Publications.

The production of tin in various parts of the world, C. M. Rolker. 16th Ann. Rept. U. S. Geol. Survey, pt. 3, 88 pp., pl. 19, 1895.

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Report on the New Red of Bucks and Montgomery counties, B. S. Lyman. Geol. Survey Pa., Summary Final Rept., pp. 2589-2638, pls. 600-611; author's ed., 1895.

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Occurrence of tellurium in oxidized form associated with gold, Richard Pearce. 4 pp.; read before the Colorado Sci. Soc., April 1, 1895.

The soils of Texas— a preliminary statement and classification. E. T. Dumble. Trans. Texas Acad. Sci., pp. 25-60, 1 map, 1895.

Notes on the Texas Tertiaries, E. T. Dumble. Ibid., pp. 23-27, 1894.

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Memoirs Am. Museum Nat. Hist., vol. 1, pt. 2. Republication of descriptions of fossils from the Hall collection in the American Museum of Natural History, from the Report of Progress for 1861 of the Geological Survey of Wisconsin, by James Hall, with illustrations from the original type specimens not heretofore figured, R. P. Whitfield. Pp. 39-74, pls. 4-12, Aug. 10, 1895.

CORRESPONDENCE.

THE SOURCE OF THE MISSISSIPPI. The attention of geographers has recently been called frequently to this subject through the widely published claims of captain Willard Glazier. Many have questioned the justness of these claims, and the Minnesota Historical Society authorized a careful survey under its auspices. The result was published by the state, as one of its volumes of "Collections," in which, written by Mr. J. V. Brower, the claims of Glazier were not admitted. This volume embraces a very full discussion of this question, with maps and other illustrations.

Lately captain Glazier has revived his side of the discussion* in a finely illustrated book of over 500 pages.

In this new volume he strongly insists on the verity of his discovery and the justness of his claim that lake Glazier is the true source of the

**Headwaters of the Mississippi.* Rand, McNally & Co., Chicago and New York, 1894.

Mississippi river, and he has the testimony of his 14 companions, both joint and individual, supporting him in his claim. As the case is presented by him he makes a strong showing and one that will be apt to influence geographers in his favor.

It seems the essential points at issue are:

1. Is the Nicollet creek longer or shorter than the newly described creek "Excelsior," which feeds lake "Glazier?"

2. Can Glazier be considered the discoverer of the lake which he has named after himself?

In respect to the first, it should be stated that, as it now appears, neither Schoolcraft, nor Nicollet, nor Chambers ever saw the creek that enters Itasca lake from Elk lake (Glazier lake). Glazier seems to be correct in making that claim. It is overgrown with rushes at its mouth, and its debouchure is not at the head of the main valley. Nicollet creek is so plainly that which drains the principal valley that the existence of another creek uniting with this valley at a mile or so further northeast was not suspected and has remained unknown to geographers. This superiority of the Nicollet creek as the drainage course of the main valley is evidenced in the difference in size of the two creeks. Glazier himself states that the Nicollet creek at its mouth is 10 feet wide and 2½ feet deep. The creek that drains the Elk Lake valley is stated by him to be 7 feet wide and 3 feet deep, by which it appears, on his own statement, that nearly 20 per cent. more water would be discharged by the Nicollet creek than by the creek that drains Elk lake. This is on the supposition that they have the same velocity, but judging from the descriptions the Nicollet creek is much more rapid than the Elk Lake creek, and may reasonably be supposed to carry twice as much water.

The gathering ground of the waters that feed Elk lake and enter Itasca lake by way of the outlet of Elk lake is stated by Glazier to extend southward from Itasca lake 14,106 feet. The same extension for the waters issuing by way of Nicollet creek is given by Glazier at 7,307 feet. Thus the greater creek has, by his showing, the smaller valley and the shorter course, and the less importance as a tributary of the Mississippi. It seems questionable whether, whatever the relative importance of these creeks, a creek having in August a width of 10 feet and a depth of 2½ feet, could be said to extend, for its source and supply, only to the distance of a mile and three-eights from its debouchure. If it there be found issuing from a "spring" it would be the prompting of a truly scientific mind, in pursuit of the source of the Mississippi, to look a little further. If on further search he should find a stream disappearing, at a short distance up the valley, by entering into subterranean passages, it would be almost impossible for him not to assign that as the source of the water issuing at the "spring."

It should also be stated, in respect to the first of the considerations mentioned, that such has been found to be the case, by more than one observer who has described the waters of Nicollet valley. Nicollet creek runs through a succession of small lakes, marshes and subterranean, at least non-visible, passages, which have been described as constituting

one valley, whose drainage, greatly obstructed by peaty accumulations and hid from sight, really should be called one stream. This is the view that has been taken by the Minnesota Historical Society, under the guidance of Nicollet and after the careful survey of Mr. J. V. Brower, superintendent of Itasca state park. Mr. Glazier, however, in his late publication traces Nicollet creek only up to the great "spring," thus giving it only a length as stated of 7,307 feet. On the contrary it may be recalled that in northern Minnesota such obstruction of the courses of streams is not uncommon. The writer has known many instances. Bogs sometimes cover the direct drainage courses of streams, and on these bogs bushes of considerable size are sometimes found growing. Streams disappear in such places, but they reappear at lower points. The St. Louis river, which enters lake Superior at Duluth, was formerly permanently hid from sight for the greater part of a mile in the vicinity of Cloquet, by passing under floating vegetable matter, a veritable raft, on which grew small birches and willows. All streams which drain a rich country in which vegetation is abundant and easily detached are liable to such interruption, or to such "subterranean" passages. Such accidents do not destroy their identity and cannot be said to terminate their courses as continuous streams. It appears, according to all the testimony, that Nicollet creek suffers such obscuration. If it be allowed its legitimate southward extension, according to Mr. Brower, its extent is considerably more than the extent of the valley drained by Excelsior creek. Mr. Glazier entirely ignores the upper portion of Nicollet creek.

In respect to the second question, Can Glazier be considered the discoverer of the lake to which he has given his name?, we can but answer *No.* It is a lake, of large size for the nature of the surrounding country, and it is very singular that neither Schoolcraft nor Nicollet ever saw it. They had Indian guides and were in search of the same end—the source of the Mississippi—but they were not conducted to it. On the other hand their guides led them to the Nicollet valley. But in 1875 this lake was discovered and its size was mapped by the officers of the United States land survey, under direction of Gen. J. H. Baker, of St. Paul. It was given the name which was current, viz., Elk lake,* and as such it appears on the government plats. It has been supposed also that Julius Chambers entered the same lake in 1872, but Mr. Glazier makes it to appear quite doubtful, showing that the description given by Chambers applies better to one of the lakes of Nicollet creek. However, that Glazier was antedated, by six years, by the U. S. Government surveyors even Glazier himself does not deny. He bases his claim to priority on the ground that their business was not to seek the source of the Mississippi, and that they did not trace out its feeders, and that they did not publish their exploits in a manner commensurate with

*The statement has been made, apparently on the authority of Schoolcraft, that Itasca lake was formerly called Elk or *Omoshkos* lake. But it is difficult to affirm that on the authority of Schoolcraft when later authorities are considered. Ozawindib, his guide, said "*Omoshkos*" when Schoolcraft pointed up the west arm of Itasca lake, and he seems now to have referred to the lake beyond Itasca lake, where deer and moose tracks were found so numerous by Glazier.

their importance. Should it be decided that these defects really annul their priority of discovery, there is no doubt that Glazier's claim would at once be admitted.

Mr. Glazier's second volume is a very creditable production. It is probable that, had his first volume been issued with as close an adherence to fact and with as careful regard to the rights of earlier authorship, and to the usages of good literature, it would have received better acceptance. There are serious defects in this, of which it is here only necessary to mention one on page 270, in which the author speaks of Prof. A. Randall as being connected with "the Geological Survey of Minnesota" before Minnesota was yet a state.

All in all, the author, on the basis of the facts which he himself publishes, can hardly be admitted to have established his principal thesis, viz., that he discovered the true source of the Mississippi in 1881. If the true source be not Itasca lake, it must be either the head of Excelsior or of Nicollet creek, and of these Nicollet creek has the stronger claims. If, however, we admit that it be Excelsior creek, that has but recently been fully defined. If Elk lake be supposed to have the honor of standing at the source of the Mississippi, that lake was surveyed and mapped six years prior to Glazier's visit. N. H. WINCHELL.

WARM TEMPERATE VEGETATION NEAR GLACIERS. In the July number of this magazine (pages 65, 66) Dr. George M. Dawson supposes that, if the ice-sheet still remained over the country north and northeast of Toronto and lake Ontario when the interglacial beds of the Don River valley in Toronto and of Scarboro' Heights were deposited, the district must have had "killing frosts nearly every clear night during the summer." Similarly Prof. A. P. Coleman asks, in the last number of the Journal of Geology (page 640), "Can any one believe that meantime, while elms and oaks and maples, not to mention the papaw, were growing along the Don, the ice-field, with no lofty slopes to supply gathering ground for névé, was lurking a few miles off, ready to advance and overwhelm the deciduous forests?"

To this inquiry the present writer replies, Yes, that he holds this as the most probable explanation of the repeated accumulations of till above the stratified and fossiliferous beds; but No, concerning the absence of lofty slopes, by which he thinks that the predominantly wasting ice border rose probably to the altitude of 5,000 feet within 100 miles from its edge while being dissolved by the warm Champlain climate with somewhat lower altitude of the land than now. If the retreat of the ice-sheet from the northern United States and Canada occupied, as I think, some three to five thousand years, disappearing earliest from the upper Missouri and Mississippi basins, and latest from New England, the province of Quebec, and Labrador, the extension of a warm temperate flora and fauna could well keep pace with the glacial recession, so that, as on the waning Malaspina ice-sheet, a flora like that of the same latitude to-day, and concomitant temperate molluscan and insect life, may well have thrived up to the very boundary of the ice, or perhaps in the case of the plants and insects even extending as in Alaska upon the drift-covered ice border.

Darwin noted, in his narrative of the voyage of the Beagle, that glaciers in the fjords of southern Chile reach down to the sea level within nine degrees of latitude from where palms flourish. Prof. W. O. Crosby tells me of his observations of fine orchards of cherries and other fruits cultivated close to the limits of the large local fields of ice and névé in Norway, one of which has an area of about 500 square miles. In the Alps the glaciers end only a few hundred feet from productive fields and gardens of flowers. Still more like the condition of North America and Europe during the recession of their Pleistocene ice-sheets is the vast fertile plain of India, enjoying a tropical climate, while within a short distance along its northern side, and farther west and east for an extent of 1,500 miles, runs the almost impassable Himalayan range, with valleys bearing glaciers and summits crowned with perpetual snow.

The proximity of the very cold Himalayas does not bring frosts to the neighboring tropical plain. In like manner the ice-sheet still lingering on northern Ontario, New York, and New England, did not cause a very frigid climate to prevail in the winters, nor nights of frost in the summers, on the windward low region of the Laurentian lakes whence the ice had recently retreated. WARREN UPHAM.

Cleveland, Ohio, Oct. 10, 1895.

PERSONAL AND SCIENTIFIC NEWS.

THOMAS JAMES SLATTER, F. G. S., a geologist of Evesham, England, died on August 1st.

DR. HERMAN CREDNER has been promoted to a full professorship of geology and paleontology at Leipsic.

MR. H. P. PARMELEE, a geologist of Cripple Creek, Colorado, is spending a few months in Charlevoix, Michigan.

DR. W. S. STRONG, of the University of Colorado, has accepted the professorship of physics and geology in Bates College.

DR. CHARLES R. KEYES, state geologist of Missouri, and MR. H. FOSTER BAIN, assistant state geologist of Iowa, recently spent a few days in Minneapolis.

DR. F. W. SARDESON, who has been engaged during the past year in the study of paleontology at the University of Freiburg, has returned to his home in Minneapolis.

MR. W. N. MERRIAM, of Milwaukee, and MR. J. PARKE CHANNING, of New York, have returned from an extended examination of mineral lands in northern Minnesota.

DR. H. J. JOHNSTON-LAVIS, in the September number of the Scottish Geographical Magazine, presents an article on the geology, agriculture and economics of Iceland.

HENRY B. KUMMELL, Ph. D. (University of Chicago, 1895), has been appointed assistant geologist on the New Jersey Geological Survey. His address is Trenton, N. J.

MR. EDWIN GOODWIN, a graduate of the School of Mines of Columbia College, has been appointed professor of mining and geology in the University of Idaho at Moscow, Idaho.

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its meeting for 1896 in Liverpool. In 1897 the Association will meet in Toronto by special invitation from that city.

SIR WILLIAM DAWSON, in the October number of the Geological Magazine, presents the first of a series of papers entitled "Review of the Evidence for the Animal Nature of Eozoon Canadense."

PROF. EDWARD W. CLAYPOLE, of Buchtel College, has returned home after a visit to England, during which he attended the meeting of the British Association for the Advancement of Science at Ipswich.

MR. A. H. ELFTMAN, of the University of Minnesota, has returned from a brief trip along the north shore of lake Superior. The special object of this trip was an examination of some of the well known anorthosites of the Keweenawan.

THE MEXICAN GEOLOGICAL COMMISSION, of which A. del Castillo is director, has recently issued a pamphlet of 48 pages, with plates and a geological map, entitled "Scientific Expedition to Popocatepetl," by José G. Aguilera and Ezequiel Ordoñez.

DR. A. E. FOOTE, of Philadelphia, died at Atlanta, Georgia, October 11th. In 1876 Dr. Foote began to deal in minerals and scientific books and since then his business has grown to large proportions. The business will be continued under the management of Mr. Warren M. Foote.

JAMES CARTER, F. R. C. S., F. G. S., of Cambridge, England, died on August 31st. He was recognized as an authority on the fossil Decapod Crustacea; for some time he was engaged in collecting materials for a monograph on that group, and has left his manuscript in an advanced state.

PROF. JOHN MILNE, the well known seismologist, announces that he has established a small station at Shide Hill House, Shide, Newpoert, Isle of Wight, for the recording of earthquakes having an origin in distant localities. Communications for the Transactions of the Seismological Society and for the Seismological Journal should be sent him there.

MR. WARREN UPHAM, who has been engaged during the past half year as librarian of the Western Reserve Historical Society in Cleveland, Ohio, has accepted a similar position as librarian and secretary of the Minnesota Historical Society in St. Paul, to enter on his duties there during the present month. This library is in the State House and has about 60,000 volumes, including sets of all the newspapers published in Minnesota from their beginnings.

THE COUNCIL OF THE GEOLOGICAL SOCIETY OF AMERICA has determined that the eighth winter meeting of the Society shall be held in Philadelphia, beginning on the afternoon of Thursday, December 26th, 1895. More detailed information regarding the meeting will be sent to fellows in due time.

M. CHARLES BOUCHARD has lately announced that he has examined spectroscopically the gases from three sulphurous springs in the Pyrenees and that in one he found the characteristic lines of both argon and helium, in one of helium alone and in a third helium and an unknown substance characterized by lines in the orange and red.

"TABLES FOR THE DETERMINATION OF MINERALS by physical properties ascertainable with the aid of a few field instruments, based on the system of Prof. Dr. Albin Weisbach, by PERSIFOR FRAZER, Docteur ès-Sciences, etc., etc. J. B. Lippincott Co." This book, printed first in 1874 and of which three editions have already been exhausted, is undergoing a thorough overhauling for a fourth edition which will appear shortly and which will be reviewed in this journal then.

DR. GERHARD HOLM'S article, "Om Didymograptus, Tetragraptus och Phyllograptus," which appeared in Geologiska Förenigens i Stockholm Förhandlingar (Bd. 17, Häfte 3, No. 164, pp. 319-359, 1895,) and was reviewed in the AMERICAN GEOLOGIST (vol. 16, pp. 58-59, July, 1895), has been translated into English by Messrs. G. L. Elles and E. M. R. Wood and is being published in the Geological Magazine. The first part appeared in the October number of that journal.

MR. C. P. BERKEY, instructor in mineralogy in the University of Minnesota, is at work on a detailed geological and topographical map of a district along the St. Croix river on the boundary between Wisconsin and Minnesota. Here occurs the well known unconformity between the igneous rocks of the Keweenawan and the overlying strata of the Upper Cambrian. Mr. Berkey expects especially to make a chemical investigation of the diabases at this point, with reference to alteration products.

THE BROOKLYN INSTITUTE OF ARTS AND SCIENCES has issued a prospectus for 1895-'96 which gives preliminary announcements of lectures, courses of instruction, etc., for the year. Lectures are announced in geology, for the first Monday evening in each month, by Messrs. T. C. Mendenhall, R. S. Woodward, C. D. Walcott, J. F. James, C. S. Prosser, W J McGee, W. M. Davis and D. S. Martin. In the mineralogical department the following gentlemen will lecture: Messrs. W. O. Crosby, S. L. Penfield, W J McGee and A J. Moses.

DR. PERSIFOR FRAZER, who obtained the one hundred subscribers which were required in order to secure the geological map of Europe of the International Geological Congress

for the United States with the same concession as to price which was enjoyed by the citizens of other "large countries" whose governments furnished subsidies to the work, is in correspondence with the committee of publication, and hopes to be able to announce to the survivors of those subscribers in the next number of the AMERICAN GEOLOGIST the manner in which their subscriptions should be paid and the separate copies distributed to their several owners.

THE NORTHWEST MINING ASSOCIATION met in the city of Spokane, Washington, October 2d, as stated in this journal last month, at which time a permanent organization was effected. There was an interesting session of two days' duration, pertinent subjects being discussed. The attendance was large, about three hundred delegates being present. The following named officers were elected: G. B. Dennis, president; A. P. Curry, first vice president: L. K. Armstrong, secretary; F. L. Kershaw, assistant secretary: W. J. C. Wakefield, treasurer. Several committees were also appointed, as were the second vice presidents. The meeting adjourned after the members had voted to hold the next annual meeting in Spokane next year on the same date, when a large and permanent ore exhibit will be arranged from all the districts of Washington, Idaho, Oregon, Montana and British Columbia.

THE AMERICAN INSTITUTE OF MINING ENGINEERS held its sixty-ninth meeting at Atlanta, Georgia. Eight days, from October 8th to 15th, were devoted to the meeting and to excursions to points of interest in the vicinity of Atlanta. The following papers bearing on geological subjects were presented:

The present development of gold mining in the southern Appalachian states. H. B. C. NITZE and H. A. J. WILKINS.

The gold regions of Georgia and Alabama. W. M. BREWER.

The mineral resources of northern Georgia and western North Carolina. W. P. BLAKE.

Kaolins and clays of the south Appalachian region A. J HOLMES.

Underground currents of drinking water. A. J. HOLMES.

Notes on certain water-worn specimens. F. C. HOLMAN.

The geology of northern Georgia and Alabama. C. WILLARD HAYES.

Monazite deposits of North and South Carolina. C. A. METZGER.

A section of Rich Patch mountain at Iron Gate, Va. E. J. SCHMITZ.

The phosphates and marls of Alabama. EUGENE A. SMITH.

Precious stones of the South. GEO. F. KUNZ.

Chrome ores in the southern Appalachian region. WM. GLENN.

The eastern coal regions of Kentucky. GRAHAM MCFARLANE.

Onyx marbles. COURTNEY DEKALB.

Folds and faults in Pennsylvania anthracite beds. B. S. LYMAN.

The geological structure of the western part of the Vermilion range of Minnesota. H. L. SMYTHE and J. R. FINLEY.

The form of fissure walls as affected by sub-fissuring and by the flow of rock. WM. GLENN.

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[CRUCIAL POINTS IN THE GEOLOGY OF THE LAKE SUPERIOR REGION. No. 10.]

COMPARATIVE TAXONOMY OF THE ROCKS OF THE LAKE SUPERIOR REGION.

By N. H. WINCHELL, Minneapolis, Minn.

It remains now, in concluding this review, to gather together in a more concise form the views that have been presented, and to show what contrasts they present with the taxonomy of Messrs. Walcott and Van Hise. These geologists are not themselves primarily responsible for the classification which they have adopted, although they construct their schemes and adjust their arguments upon it. They inherited it from the Wisconsin survey in part and in part have allowed it to grow up from an artificial and fortuitous set of conditions arising largely from personal preferences and prejudices engendered by the literature of the last fifty years. It is probable that the understanding of the stratigraphy of the Lake Superior region, at the horizon of the lowest Paleozoic rocks, will serve in some measure, as in the understanding of the pre-Taconic, in applying the key to the stratigraphy of these terranes in the eastern part of the United States. The greater abundance of the superficial drift in New England, the greater complexity of the early folding and the consequent metamorphism, the more limited scope of the early individual observations, the greater haste with which they were made on the crystalline and sub-crystalline rocks, and the active zeal the observers to support personal opinions, resulting in

partisan and sometimes hostile schools, did not facilitate the solution of the structural problems that confronted the geologist at this horizon fifty years ago, but they all conspired to throw about the geology of the sub-Silurian for many years an impenetrable fog which no one was willing to attempt to pierce. Later these problems have arisen in the Lake Superior region, under different conditions, and they have been gradually unfolding under the labor of numerous workers, spread over a much wider area and advancing with greater precision and deliberation, with more means at their disposal and better geological training to fit them for the task. If they have made more satisfactory headway, with more coöperation and harmony, it is because of different stimulants and more genial conditions rather than more skill or greater industry. Furthermore, they have had the experience of their predecessors, both as a guide and as a warning.

The following table exhibits at a glance the contrasts that appear between the classification of Messrs. Walcott and Van Hise and that of the writer. The geologist who has followed the argument of these papers will have learned what are the main reasons for not accepting the taxonomy of the "Correlation papers" lately issued. If these objections are valid, there is a necessity for revision and careful re-examination in the field at points where the crucial facts can be seen.

There are two leading and fundamental differences between these classifications, which do not relate in the least to the question of nomenclature, although nomenclature may have been one of the original elements predisposing one way or the other. These are:

1. The existence or not of a great erosion interval between two sandstones, viz., between the upper member of the Keweenawan, which consists of red erosible sandstones, and the bottom of the horizontal sandstone, which, excepting its basal conglomerate at overlap contacts, also consists of red erosible shales and sandstones.

2. The integrity or the dismemberment of the Keweenawan

In reference to the first, while it is not necessary to rehears
the argument in full, it may be well to repeat that all t
non-conformable contacts of the horizontal sandstone on t
trap of the Keweenawan, and also those on the quartzytes

Classification of the Lake Superior Formations.

Formations.			Kinds of rock and localities.	Formations. (According to Correlation papers).		Kinds of rock and localities. (According to Correlation papers).
	UPPER CAMBRIAN. *Olenus zone*	St. Croix.	Trap on limestone and sandstone, Nipigon.	UPPER CAMBRIAN.		Sandstone, Pictured Rocks.
		Eastern sandstone.	Light colored and also red sandstones. Eastern sandstone.	Eastern sandstone.		Limestone and sandstone, St. Croix valley.
		Lake Superior sandstone.	Conglomerates at contacts on older rocks.	Potsdam sandstone.		Sandstone and conglomerate, St. Louis valley.
		Nipigon formation.	Sandstones at Montreal river; St. Croix valley; St. Louis valley.	*Dicellocephus zone.* (Low. Cambrian wanting)		Low. Cambrian Erosion-interval here.
		(The Dicellocephalus "Potsdam" of New York.)				
Progressive subsidence.	KEWEENAWAN. *Parradoxides zone.*	Keweenawan. Traps and underlying Quartzyte and Conglomerate.	Trap flows at Montreal river. Quartzyte, at Bessemer, Mich.; Barron Co., Wis.; Pipestone, Minn. Conglomerate, at Barron Co., Wis.; New Ulm, Minn.; Grand Portage I.; St. Louis valley; Isle Royal.	ALGONKIAN (in part) (or Pre-Cambrian.)	Keweenawan or Nipigon series.	Sandstones and shales Montreal river, Nipigon bay. Trap flows. Gabbro and Anorthosyte Duluth to Pigeon Point. Quartz porphyry and Quartz porphyry conglomerate. Mesabi gabbro and red rock. Quartzyte.
		Potsdam at Potsdam, N. Y., and eastward to the Au Sable river.	Quartzyte at Potsdam, N. Y. Quartzyte, Merillan, Wis			
		Non-conformity.	Non-conformity.		Non-conformity.	Non-conformity.
TACONIC (or Middle and Lower Cambrian.)	ANIMIKIE. *Olenellus zone*; *Foraminifera.*	Animikie slates.	Quartzytes and Black slates at Grand Portage bay and Pigeon point.			Slates, changed to mica schists locally.
		Pewabic and Wauswaugoning quartzytes.	Gabbro dikes and laccolites, Duluth to Pigeon point.			Iron-bearing rocks.
		Penokee series.	Quartz porphyry and Augite syenite.		Penokee.	Eruptives (basic).
		Mesabi iron range.	Acid lavas.		Animikie.	Quartz-slate.
		Misquah hills.	Iron-bearing rocks.		Upper Huronian	Quartzyte.
		Gabbro and Anorthosyte range.	Cherty limestone.			Conglomerate.
		Norian.	Quartzyte and conglomerate at the base of the Animikie.			
		Upper Laurentian.	Massive diabases.			
		Bohemian range and South Copper range in Michigan.	Hardened and tilted black slates, Brule L.			
		Minong range, Isle Royal.	Changed clastics of Pigeon point.			
The Great Non-Conformity.						
ARCHEAN.	Ontarian	Keewatin.		ARCHEAN.		**Lower Huronian.**
						Un-conformity.
		Coutchiching.				**Mareniscan.**
	Laurentian.					**Laurentian.**

Baraboo, Wis., that have been appealed to, are more reasonably explainable on the hypothesis of a progressive subsidence of the region and submergence beneath the ocean, incident to an epoch of voluminous igneous ejection. Furthermore, this subsidence is not a hypothesis; it is proved. In that case there may have been no atmospheric erosion-interval, but, after local fracturing of the ocean's bed and the outpouring of lava, sedimentation was resumed and resulted in alternating igneous and clastic strata. Toward the end of the epoch of disturbance fractures occurred in some places without the issue of lava, while in other places lava was poured out in vast amounts. The former may be seen on the south side of the lake, as at Keweenaw point, and the latter in the Nipigon region.

It might be remarked, in addition to the objections already urged against a great erosion-interval at this horizon, that, if the Lower Cambrian is entirely wanting in the Lake Superior region, the top of the pre-Cambrian there presents an anomaly. The top of the pre-Cambrian is usually a very firm and even a crystalline rock. Its great age necessitates this—i. e., if the Cambrian be not limited at the Olenellus zone. Here, however, the hypothesis of the Wisconsin survey, adopted by the U. S. Geological Survey, reveals the top of the pre-Cambrian as an erosible red sandstone with an upper limit that is wholly unknown, sometimes tilted and sometimes horizontal, its contact with the horizontal Cambrian above *never having been seen*. At the same time, the base of this erosible sandstone is equally elusive, since it vanishes in a mass of conformable eruptives, whose appearance is so fresh that they have been classed as Mesozoic by several geologists. On so slender a thread does this important hypothesis hang.

In regard to the separation of the Keweenawan system as defined by Irving, into three parts, Lower, Middle and Upper Cambrian, each marked by its eruptive rocks and characterized by its own clastics, there seems to be not only much evidence, but even a necessity for such differentiation. No student of the geology of the Lake Superior region can avoid the conviction of something anomalous and bizarre in the composition and structural features of the Keweenawan as it has been described and mapped. Instead of the individual

and simple entity which it appears to be, it is a complex system. The difficulties of the region are great, but sufficient has been learned to warrant some leading distinctions. The unique and definite conception which may be derived from the published descriptions of the Keweenawan gradually crumbles away when one goes into the field and carefully notes the facts. He first experiences a profound bewilderment, from which he emerges with sharpened eagerness to solve the conflict between his preconceived notions and the apparently anomalous facts. This pursuit, in the case of the Minnesota survey, has been continued during several years. Occasionally new data have been discovered which have led to changes in interpretation, and later discoveries have necessitated still further improvements. No attempt has been made, however, until now to group the entire system in a consistent structural scheme. Even now the discussion is but partial and the classification provisional. It has yet to be rounded out with a fund of fact that cannot here be presented, and it may have to be still further changed, but as a classification it rests on a large amount of field work and of comparative study of the published literature.

In concluding this series of papers it is interesting to note how beautifully the grand succession of geologic events in America in Cambrian time compares with the succession in Europe. Dr. Hicks has recently remarked as follows:*

There can be no doubt that the genera *Olenellus*, *Paradoxides* and *Olenus* in the areas where they have been found to succeed each other in conformable sediments do mark very definite periods in the world's history; but such arbitrary lines are not natural, and we must expect to find from time to time that the limit assigned to a genus will have to be extended as new areas are being explored. Where a genus, which has been sufficiently abundant to characterize a main zone, disappears suddenly, there is usually some indication in the deposits of at least a slight physical change. At St David's this is particularly marked, for immediately below the lowest *Paradoxides* horizon a fine conglomerate containing angular fragments of volcanic material occurs, and this I have taken as the boundary line between the Caerfai (*Olenellus* beds) and the overlying Solva (*Platonian* and *Paradoxides* beds). Again at the top of the Menevian, and separating it from the overlying Lingula flags (*Olenus* beds), massive grits succeed black slates and in these grits again we meet with volcanic materials. Were it not for these changes

*Life Zones in Paleozoic Rocks, Geological Magazine, dec. iv, vol. i, p. 404, 1894.

I doubt not the genera would have a greater vertical range, and at certain horizons also intermediate forms would be found.

The succession of these three sub-faunal zones has been well established in America. But the cause of the changes from one to the other has been problematical. As indicated by Dr. Hicks, such cause can be seen in the nature of the sediments, where the strata are conformable, but where they are entirely non-conformable at definite horizons it can be seen, especially in the Lake Superior region, in the succession of eruptive epochs whose activity is attested not only by the faunal changes but by the presence of the eruptive masses in great volume.

The writer has been compelled to limit the present discussion to the rocks that lie above the great non-conformity at the base of the Taconic. To fully review the classification of the "Correlation papers" would require another series devoted to the Archean, in respect of which are inconsistencies and assumptions, in the publications here reviewed, which can only be considered detrimental to the progress of geology. These chiefly center in and revolve about the introduction, the definition and the application of the term Algonkian, the whole constituting, in brief, one of the greatest mistakes of American official geology. With this brief expression of opinion, the writer is compelled to forego the discussion of this portion of the subject.

Minneapolis, April 2, 1895.

SUPPLEMENTARY NOTE. In writing of the Canadian localities of the Taconic eruptives (vol. xv, p. 356, June, 1895), by an unfortunate oversight the earliest mention of the rocks of Mt. Stephen, and the eruptives found therein, was omitted by the writer.

The first announcement of Cambrian fossils from this region was made by Mr. H. H. Winwood (on the authority of Dr. Hicks) in the London Geological Magazine, May, 1885. The first *discovery* of such fossils was made by Dr. G. M. Dawson, in August, 1884. These, as well as those afterwards collected during Mr. Winwood's visit (at the time of the British Association excursion), were examined by Mr. C. D. Walcott, who recognized *Olenellus gilberti* and *howelli* and *Olenoides laevis*. Publication occurred shortly afterward in the Annual Report Geol. Sur. Can., 1885, (pp. 119B, 139B). Mr. McConnell, therefore, who collected later and more fully from the same place, knowing this earlier announcement, was in no haste to place his discoveries on record.

It is, further, of interest to note, that in the same report (pp. 51B, 157B, etc.), contemporaneous igneous rocks occur amongst these strata in this part of the mountains, thus adding another, and quite important locality where in Canada a similar history prevailed.

Still later, Mr. A. P. Low, of the Canadian survey, has made an important announcement (Summary report of operations of the survey for 1894, G. M. Dawson, director, Ottawa, 1895; reviewed in the Am. Geologist, Sept., 1895, p. 199). In the course of his explorations in the Labrador peninsula, he discovered a great and hitherto unknown area of Taconic rocks, "extending north-northwest from north latitude 53 degrees to beyond the west side of Ungava bay. These rocks are made up of a great thickness of conglomerates, sandstones, slates, shales and limestones, together with intrusive igneous rocks. Their chief economic value is due to the immense amount of bedded iron ore found along with them. The ores are chiefly specular and red hematite, together with beds of siderite or carbonate of iron. Thick beds of fine ore associated with jasper were met with in many places on both the Ungava and Hamilton rivers; and the amount seen runs up into millions of tons. Owing to their distance from the seaboard, these ores at present are of little value, but the time may come when they will add greatly to the wealth of the country." The reviewer adds: "The similarity of these areas with the valuable mining districts of northern Michigan, Wisconsin and Minnesota seems especially noteworthy." It seems likely, therefore, that, with the great Norian anorthosytes for which Labrador is well known, that peninsula will yet develop into one of the interesting localities of Canadian Taconic rocks, comparable with the Taconic of the Lake Superior region.

The reader will please make the following errata in this series of papers:

P. 299, vol. xv, seventh line from the top, for "distributed," read disturbed.

P. 304, vol. xv, seventh line from the top, for "Adirondack," read Taconic.

P. 18, vol. xvi, last line in the foot note, for "xiv," read xv.

P. 150, vol. xvi, twelfth line from the bottom, for "ever," read even.

P. 210, vol. xvi, third line from the top, for "applicable," read capable.

P. 212, vol. xvi, between the fifth and sixth lines from the bottom, a line has been omitted: supply, Keweenawan and the reddish sandstone of the.

Paris, Oct. 16, 1895.

RIVER VALLEYS OF THE OZARK PLATEAU.

By Oscar H. Hershey, Freeport, Ill.

In traveling over the Ozark plateau or so-called Ozark mountains in Missouri and Arkansas, the writer was surprised at the comparative narrowness of the immediate valleys of the streams, and was led to make an investigation of the subject, of which the following observations and conclusions are the result. The study is far from complete, but it is hoped that this paper may contain some suggestions for future researches into the geomorphology of the Mississippi basin.

The Ozark region has been frequently described, and the majority of readers are doubtless acquainted with its topography. It is essentially a plain which has been elevated into a broad, dome-shaped "uplift," and subsequently it has been sculptured by erosion into very numerous deep and generally quite narrow valleys, with narrow, steep-sided ridges between. The crest or water-shed of the plateau has mostly an undulating or moderately rolling surface, while the exceedingly hilly and mountainous country occupies the border portions of the uplift. The rock strata consist largely of magnesian limestones and intercalated sandstones of Upper Cambrian and Lower Silurian age, with cherty limestones and shales of Lower Carboniferous age resting on them toward the north, west, and southwest. The conglomerate sandstone of the base of the Coal Measures is also present, over the Burlington limestone, well within the limits of the uplift, as isolated remnants of a once more extensive formation. The dip of the strata is gentle and regular, so much so that they are perhaps more nearly horizontal than are the same formations in any other portion of the American continent.

The Jura-Cretaceous Peneplain.

It does not take the traveler in the Ozarks very long to discover that nearly all the ridges rise to about the same hight, and that, were the intervening valleys filled up to the level of the hill tops, we should have a nearly level plain. On the hard Burlington limestone areas, one will frequently look for many miles across the country and see only, in appearance, a vast timbered plain, although it is one of the roughest regions east of the Rocky mountains. This ancient and

eroded plain is not confined to regions underlain by any one formation, but passes alike over Cambrian, Silurian, and Carboniferous strata: nor is it confined to the Ozark plateau, but descends by a gentle slope to the level of the upland country which surrounds the plateau on all sides, excepting the southeast. Thence it extends across the prairies, joining the similarly channeled plains of other uplifted tracts in the eastern portion of the continent; and westward it passes across the Coal Measures until it sinks under the Cretaceous strata of the Great plains. It is the Jura-Cretaceous peneplain, which was produced by subaërial erosion during a long period approximately coinciding with the Mesozoic era. At or near the close of Cretaceous time the Ozarks did not exist, either as a plateau or mountains, but their present site was occupied by a low, marshy plain of very slight relief, probably nearly at sea level.

But there are, at widely separated intervals in the Ozark region, small hills and short ridges, which rise from twenty-five to fifty or perhaps occasionally one hundred feet above the level of the peneplain. They are generally composed of sandstone, and in the western part of the region are frequently largely made up of coarse conglomerate which belongs to the basal member of the Coal Measures. When of some material which powerfully resists erosion, they are steep-sided and quite prominent, affording extensive views over the surrounding country. These mounds and small ridges generally occur on the watershed between the principal streams, but are also found far within the broken country, often standing on the edges of the deepest valleys.

The examples of these ridges and knobs which I have examined particularly are on the watershed between the Osage and Missouri rivers, on the crest or general watershed of the plateau between Lebanon and the Arkansas line, in the broken country of Barry and Stone counties, and beyond the Ozark uplift in western Missouri and southeastern Kansas. But from maps and other sources I learn that they are widely scattered over the Ozarks in both Missouri and Arkansas. Belonging to the same class are doubtless the "mounds" in Bates, Cass, Johnson, Lafayette, and other counties of western Missouri, described by Broadhead as "ridges several miles long, and oc-

casionally a single mound 80 or 100 feet above the lower plains, with an area of probably half an acre on the summit. Other mounds may be near, or distant two, five, or fifteen miles. The visibly depressed or eroded area may be a prismoid 100 feet deep by five or ten miles in one direction and twenty miles or more in another."*

On the main watershed I find generally very long, sometimes narrow, and again broad ridges, which merge into the broad plain-like country of the crest or, as it has been called, plateau portion of the Ozarks. Also from Scholten in Barry county, extending several miles toward the northwest, there is a narrow ridge, composed of Carboniferous sandstone and conglomerate, rising from 25 to 50 feet above the surrounding upland country. This is entirely isolated, being distant about ten miles from the plateau country near Aurora.

The mounds and short ridges here discussed may be specifically classed with the monadnocks of New England: and they may be said to bear the same relation to the surrounding peneplain as do the "mounds" of the lead region of Wisconsin, Iowa, and Illinois. Although much less conspicuous features of the topography, their existence is equally significant with the other members of the class named.

There is another series of elevations on the surface of the Jura-Cretaceous peneplain. For examples of these I shall draw chiefly from the counties of Barry and Stone, in the southwestern part of Missouri. The upland country here is composed of the hard cherty limestones of the Kinderhook and Burlington formations, which have resisted erosion better than the magnesian limestones to the east, and hence better preserve the original outlines of the peneplain. It has already been remarked that the hill-tops in the Burlington limestone areas rise to a nearly uniform hight. But close observation shows that the ancient plain thus represented is not now level, but rises very gently from the vicinity of the streams to the watersheds. The rate generally does not exceed a few feet per mile, and the exceedingly shallow basins thus formed are nearly imperceptible. Occasionally several streams head in some slightly undulating elevated tract of small extent, and flow outward to all points of the compass. Such a tract occurs

*American Geologist, vol. xiv, p. 388, Dec., 1894.

at the head of Pine run in Stone county, and overlooks much of the surrounding country. It is composed of strata yielding more readily to surface erosion than the sandstone ridge at Scholten, and hence is less prominent. Its topography resembles that of the plateau country, of which it may be considered an outlier.

Only in one way can the steep-sided sandstone mounds and ridges have been produced, namely, by erosion. There are several ways by which the shallow basins on the peneplain may have been produced. They may be due to warpings of the earth's surface since the post-Cretaceous elevation of the Ozarks. Warping has certainly occurred over most of the Ozark region, but, in that particular portion of it under consideration, the strata are so nearly horizontal that no great amount of warping can have occurred. Besides, the basins form such a regular system, and have such relation to the rocky strata under them, that some form of erosion, instead of warping, will better explain all the phenomena.

These shallow basins may be supposed to have been produced by subaërial erosion since the elevation of the peneplain. The broader ridges are flat-topped and quite regular in hight. They gently descend from the sides to the center of the basin. Now, surface erosion should be fully or nearly as much at the edges of the basins as in the center. Where the edges are narrow, the effect on the streams on either side has been to depress them from 10 to 25 feet. But this is quite unlike the steady slope of a ridge from one end to another. Again, the centers of the larger basins are sometimes 50 to 100 or more feet lower than the rim. Ordinary surface erosion in a hilly country could not be the cause of this. In short, it may be said that the theory of surface erosion since the elevation of the peneplain is inconsistent with the phenomena of the basins.

One other hypothesis remains open for inspection, namely, that the almost imperceptible basins here discussed are the outlines of the hydrographic basins of the streams which flowed on the Cretaceous lowland plain. This hypothesis seems to explain all the phenomena. The baseleveling of the region was nearly complete. The rims of our basins occupy the situations of the dividing cols of the ancient

drainage system. The elevated tracts like that at the head of Pine run in Stone county, and the plateau country or crest of the Ozarks, were the higher portions of the plain, where the streams had their sources. The short ridges and mounds above described were preserved from erosion on account of the hardness of their strata, and were the only elevations of any prominence on the ancient plain.

Tertiary Valleys.

The larger streams in the Ozark region are exceedingly tortuous and flow in comparatively narrow, steep-sided valleys, trenched 200 to 500 feet below the level of the surrounding upland. The meanders of the streams are similar in form to those produced on broad flood-plains: but in this case the valleys partake of the meandering course of the rivers, and there are practically no flood-plains, although generally a narrow tract of river swamp deposit spreads to a few times the width of the stream, and changes about from side to side as it is displaced by the river approaching the bluffs.

These river valleys are compound, consisting of a small trough excavated in the bottom of a much larger trough or valley. The duplex form of the valleys is especially noticeable in the portion of the White river basin crossing the region of Lower Carboniferous limestone. Standing on the edge of the higher upland, on the heavily timbered ridges of the exceedingly rough country locally known as the Carney mountains, and looking south across the valley of White river, one sees a broad moderately rolling plain, pleasantly diversified with cultivated lands and small tracts of timber, and bounded on the southern side beyond the Arkansas line by the pine-clad hills of the Eureka mountains. Far to the west is the still higher range of the Pea ridge, and scattered about in the cultivated lowland are timbered, cone-shaped hills or peaks, rising nearly or quite to the level of the surrounding mountainous tracts. Descending from the hills and traversing the lower but still undulating country, the traveler is surprised to find the White river occupying a small valley only four or five times wider than its stream bed, although trenched 100 or more feet below the level of the larger valley.

In the smaller valleys of the region the contrast between the two troughs is not so prominent. Along the James river and smaller streams, such as Flat creek, the plane of demarkation

between the two troughs consists of persistent though somewhat irregular terraces, known among the settlers as "bench lands," which are found near the base of the valley slopes, frequently changing from side to side as the lower trough may approach one or the other of the older valley's borders. These "bench lands" are persistent throughout that district, and to some extent throughout the Ozarks. Starting near the headwaters of the streams, they first appear as a slight relief along the sides of the valley bottom. Thence, as the main valley deepens, they rise higher above its bottom and become broader and more prominent features of the topography. The town of Galena in Stone county, Missouri, is mainly built on this terrace plane, and many of the farm buildings along the James river have been erected on its flat surface, especially where, at the intersection of valleys, it frequently runs far out in a point or cape-like projection. At Galena and in all valleys of that vicinity the hight of the terrace above the present streams averages from 50 to 60 feet; but where it connects with the broad ancient valley of White river, its elevation is considerably over 100 feet above the stream. Farther on down the latter valley in Taney county, Missouri, and in the portion of the Ozarks extending into Arkansas through which the White river flows, much of the country near the river, which is described as a very hilly upland, is in truth merely a part of the upper trough or ancient valley that has been deeply excavated by subsequent erosion.

When first observed by the writer, these terraces were thought due possibly to a diversity in hardness of the various strata of the bed-rock of the region. It was noticed that the valley above the terrace was excavated in the cherty shales and limestones of the Lower Carboniferous system, while the lower trough was trenched chiefly into the dolomites of the Ozark series. But a comparison of erosion forms in the eastern Ozarks and the western portion of Missouri made it evident that the Lower Carboniferous rocks were harder and less easily eroded than the strata of the Ozark series. Furthermore, in tracing the terrace plane up the smaller valleys, it was found to be equally well developed after the Ozark dolomites, or "cotton-rock," as they are locally denominated, had disappeared under the base of the valleys; and when these

terraces had been traced up over the Kinderhook shales onto the crinoidal limestone of the Burlington period, it became a certainty that the variable hardness of the rock had nothing whatever to do with the formation of the terraces. After the upper trough or main portion of the stream valleys had been excavated to approximately its present size and form, the entire region in which these terraces occur, which includes the Ozark plateau and much of the surrounding country, was elevated by an epeirogenic movement, which lowered the base-level relatively to the general surface, and permitted the streams to cut new valleys in the bottom of the older ones. Whatever movements may have subsequently affected the region, this elevation was to a certain extent permanent.

Isolated remnants of what appear to be terraces occur at various hights along the hillsides far above the prominent terrace here described, but they are indistinct and unimportant, and no attempt has been made to correlate them. Some probably are due to difference in hardness of the rocks; others may record slight movements of the region, while the remainder may have originated through variability in erosive power, to which all streams are liable.

The problem of locating, among the periods of geologic time, the date of the epeirogenic elevatory movement to which the lower troughs owe their origin, is rather difficult at the present stage of the study. I will, however, endeavor to indicate my opinion on the subject, and will make use of several methods for determining the age of a valley. The first is by a comparison of valleys in the Ozarks with valleys of a known age in other regions; and the second is by the stratigraphic relations of the inclosed deposits.

It is generally conceded that streams of nearly equal size, flowing with equal drainage gradients, through strata presenting the same resistance to erosion, will erode valleys approximately equal in size. Hence, also, nearly equal valleys (all conditions governing their erosion being about alike) may be considered to have been formed in essentially the same length of time. I wish to apply this principle in roughly determining the age of the valleys in the Ozarks, and shall compare the valleys of three streams in Illinois, namely, the Rock and Pecatonica rivers and Yellow creek, with four

streams in Missouri, namely, the Osage river on the northern slope of the Ozark uplift, and the White and James rivers and Flat creek on the southeastern slope of the same highland region.

The ancient or Tertiary valley of the Rock river, which is still occupied by this stream to the mouth of the Kishwaukee river, averages three miles in width and 150 feet in depth. The upper trough of the White river in Missouri averages perhaps three to five miles in width and 200 feet in depth. It will thus be seen that they are approximately equal in size; the amount of strata excavated by the White river is somewhat greater than by Rock river, but at the same time the drainage area of the former above the point of comparison is greater than of the latter. I am not so well acquainted with the valley of the Osage, but know its upper trough to be similar in size to the Tertiary valley of Rock river.

The Tertiary or preglacial valley of the Pecatonica river in northwestern Illinois—a stream comparable in size to the James river in southwestern Missouri—is from one to two miles wide and averages 150 feet in depth. The upper trough of the James river varies from a half mile to one mile in width, with an average depth of 200 feet. The Pecatonica valley is thus somewhat larger than the upper valley of the James; but the former is excavated in softer strata than the latter, and apparently required about the same length of time for the performance of the work of erosion.

Again, the preglacial valley of Yellow creek in northwestern Illinois—a stream comparable in size to Flat creek in southwestern Missouri—is 3,000 feet in width and 150 feet in depth. The upper gorge or valley of Flat creek varies from one-fourth to three-fourths of a mile in width, and averages 200 feet in depth. So they, likewise, are approximately equal in size.

Other valleys in northwestern Illinois and southwestern Wisconsin could be compared with valleys in the Ozark region with a like result. It is evident that as the valleys in the former region are about equal in size to the upper gorges or valleys in the Ozark region, when all the conditions of areas of drainage basins, drainage gradient, and rock strata are similar, they required about the same length of time for

their excavation. Now, the period of erosion of the ancient valleys in northwestern Illinois is limited, being subsequent to the period of Cretaceous baseleveling and previous to the glaciation of the region. In short, it corresponds to the Tertiary era, and I have referred to the valleys then eroded as Tertiary valleys. Similarly in the Ozark region the erosion of the upper troughs of the streams first began when the Jura-Cretaceous peneplain was uplifted, and continued to the close of the Tertiary era. These troughs are the Tertiary valleys of southern Missouri, while the nearly imperceptible basins on the peneplain are the Cretaceous valleys of the same region.

Quaternary Valleys.

The Pleistocene gorge of the Rock river below the mouth of the Kishwaukee in Illinois first came into existence on the retreat of the first ice-sheet that had overrun what is now Illinois, and it has been in process of formation, at varying rates, ever since. But it was practically completed previous to the deposition of the loess of the Mississippi valley. It averages, in the portions which are strictly post-Tertiary in age, about a quarter of a mile in width and 75 to 150 feet in depth. The lower gorge or present valley of the White river is a fourth to a half of a mile in width, and averages in Missouri 100 feet in depth. The cross-section of one is thus seen to be approximately equal to the other. Similar Pleistocene rock gorges of the Pecatonica river are an eighth of a mile wide and 60 feet deep. The lower trough of the James river near Galena averages a sixth of a mile in width and 60 feet in depth. Pleistocene gorges in the Yellow creek valley are about 400 feet wide and 60 feet deep. The lower trough in the Flat creek valley averages 600 feet wide and 60 feet deep. It is thus seen that the cross-section of the lower troughs or immediate valleys of the Ozark streams is greater than of the Pleistocene valleys in northwestern Illinois, but the difference is not very great in amount.

It must be remembered, however, that the gorges of Illinois extend through only a comparatively small portion of a stream's course, while those of Missouri extend throughout the entire length of the stream. But since the Pleistocene valleys, although quite narrow as compared with the Tertiary valleys of the same region, are from three to twenty times as

wide as the present streams, the greater portion of the period of erosion is known to have been occupied by the stream in widening its valley by meandering and undermining its walls, which take place not more than a few times more rapidly in a short than in a long gorge. My observations show that the cross-section of a gorge does not depend so much on its length as it does on the depth and on the nature of the rock. A comparison of short valleys and ravines, having nearly equal drainage areas, of Pleistocene age in northwestern Illinois, and of the age of the lower troughs in southern Missouri, shows that the latter are not many times larger than the former. In short, from an examination of all the phenomena in both regions, I feel safe in asserting that the lower troughs or present immediate valleys of the streams in the Ozark region have not required more than two or possibly three times as long for their excavation as the Pleistocene gorges and ravines of northwestern Illinois.

The earliest known glaciation of Illinois, although many times older than the last or that which formed the great moraine systems, was still perhaps nearer the middle than the beginning of the Quaternary era; and, as the erosion of the rock-gorges of Illinois has occupied perhaps three-fourths of the time since that first glaciation, its length is probably not over half that of the Quaternary era. Therefore the period of erosion of the lower troughs of the Ozark region, if only two or three times as long, would correspond approximately to the whole of this era. This reasoning is far from conclusive, but, as I hope to show, there is other and even stronger evidence that the channeling of these valleys began near the beginning of Quaternary time.

Meandering Courses of the Streams.

The cause of the exceeding crookedness of the Ozark valleys has been much discussed during the past few years, two chief hypotheses being advanced. One attributes the interminable windings of the streams to the effect on them of systems of joint planes developed in the Ozarks. While some of the minor crooks of the valleys may be due to this cause, I can find nothing but contradictory evidence in the application of this theory to the larger valleys. Slight anticlinals are locally developed in the Ozarks, but the streams maintain their

courses irrespective of their existence. The theory which seems most in accordance with the known facts is that which attributes the crooks to the former meandering of the streams on a lowland plain. I have observed that the valleys endeavor to follow the lowest portions of the ancient Cretaceous valleys or basins, which, as we have seen, supplied the conditions for the development of a most perfect system of meanders. The old Tertiary valleys are not nearly so crooked as are the streams at the present day. In general, the windings of the Cretaceous streams, as revealed by the Tertiary valleys, were of greater magnitude than at any subsequent period, and were in proportion to the size of the stream. It is assumed that, following the post-Cretaceous elevation of the Ozarks—the most profound elevatory movement which has ever affected them,—the streams trenched their valleys in the positions which they had formerly occupied on the peneplain. After cutting to the new Tertiary baselevel they spent a long period in undermining the valley walls, until they had formed a new but much more circumscribed flood-plain, about which they meandered somewhat like the streams of the present day.

As indicated by the lower troughs of the valleys, this late Tertiary system of meanders was less in magnitude than the previous Cretaceous system. This may have been due either to the more limited area of the flood-plain or to a diminished supply of water, probably in part to both these conditions. We have now reached the second step in the production of the crooks in the present rivers, for the lower or Quaternary valley winds about within the very crooked Tertiary valley. The post-Tertiary elevation appears to have been sufficiently rapid to cause the streams to cut the new valleys exactly or nearly under their old courses. In the progress of time the streams had again cut to their new baselevel, and have since widened their valleys sufficiently to allow the formation of a new system of meanders, which, however, is very imperfect as compared with the previous ones. The streams are flowing from side to side of the valley, first undermining one bluff and then the other, forming high mural precipices on the outer side of the curves and a comparatively gentle slope on the inner side. It is a system of meanders confined to too limited an area to give it free play, and were the rocky walls

removed it would probably be comparable in size to that of the Tertiary era, but not of the Cretaceous. This is the third and last step in the formation of the present courses of the streams, which, as mapped, may be considered to be the complex result of three distinct systems of meanders separated by wide intervals of time.

Comparative Straightness of the Missouri Valley.

The Missouri river flows across the northern edge of the Ozark uplift, but differs from other rivers of the region by being comparatively straight, although above the region of the uplift it has a broad valley and meanders on a flood-plain. The immediate valley of the river, from near Booneville onward, varies from one to two miles in width, and is trenched below the floor of another valley several times as large. At Jefferson City the lower gorge is perhaps about 100 feet deep, and the rim of the upper gorge or trough lies a short distance south of the city and is about 200 feet above the river.

In explanation of the comparative straightness of the Missouri valley two principal hypotheses may be examined. The first is that it is due to a straightening of the river by the ice-sheet which once covered northern Missouri and advanced to the Missouri valley, yet apparently did not extend beyond it in this region; but the valley was in existence previous to the glaciation of its northern side, as its relation to the drift shows, and was just as straight in preglacial times as now. The other hypothesis is, I believe, the one most accordant with the facts. The Missouri river did not exist in any form comparable to its present size until after the elevation of the vast Cretaceous beds of the Northwest. Hence, while the tortuous valleys of the other streams in the Ozark region are largely due to a meandering on a Cretaceous flood-plain, the Missouri river did not then exist; and subsequently in Tertiary time, when it first began to flow, it took the straightest course across the edge of the Ozark uplift.

The Lafayette Formation.

Numerous writers on the geology of southern Missouri have mentioned the existence of a local drift in the valleys, which is doubtless in large part the same deposit that I propose to describe as the probable equivalent of the Lafayette forma-

tion. It first attracted my attention in the valley of the James river, where I found that the terraces or "benches" are covered with a mixture of river gravel, broken chert, clay, and sand, which, when a fresh exposure is found, is seen to be roughly stratified. An examination of all the valleys in the region shows that this particular deposit is confined to the top and slopes of the terraces. In some places, notably at the town of Galena, it consists of large quantities of moderately coarse subangular gravel imbedded in a red clay. The thickness reaches as much as 10 or 12 feet, and its base where exposed is seen to rest on smooth and waterworn surfaces of the solid dolomite rock. In other places its materials are finer and it frequently consists of a bed of fine sand or loam nearly free from pebbles. I have picked from the sides of gullies quite large masses of transparent quartz crystals that have been formed in the loam since its deposition. The color of the clays and sands which make up the body of this deposit is prevailingly deep red, locally varying to orange. It differs from all the other deposits of the region,—from the residual clays and chert gravels on the ridges, by its being a river gravel, its bright red color, and slight but distinctly fluvial stratification; from the present river deposits, by its color, finer texture (indicating less powerful currents), and its elevated position; and from the Columbia clays by the presence of much gravel, absence of fossils, and red color.

The position of this deposit indicates that, previous to the cutting of the lower cañons or present gorges, it lined the broad, nearly level bottoms of the Tertiary valleys. In short, it is the deposit which constituted the flood-plains of the streams just previous to the early Quaternary uplifting of the region. As that uplift of the Ozarks appears to have been contemporaneous with the post-Lafayette period of elevation and rapid erosion immediately succeeding the Lafayette period of deposition, it becomes evident that our ancient river deposit must have been laid down during some part of the Lafayette period. The nature of the deposit indicates rather enfeebled erosion, and the ancient river was struggling with a mass of clay and sand, the accumulation of which was probably occasioned by a slight subsidence of the region, in conjunction with the Lafayette submergence in the Mississippi

embayment. Lithologically, the deposit under discussion bears a strong resemblance to portions of the Lafayette formation where it was laid down in valleys near the coast line of the sea in which the main body of the deposit was being formed; and, so far as I have been able to learn, the terrace deposits of the James and upper White river valleys run down the sides of the latter valley until they connect with the undoubted Lafayette deposits of the embayment region.

Assuming our correlation to be correct, we find that, during the period of submergence of the lower Mississippi region and deposition of the Lafayette formation, the erosion of the Ozarks was in a period of quiescence. The streams meandered in broad flood-plains, their power of excavation was at a minimum, and they were slowly building up a red loamy deposit, which, as it took place in the Ozarks, could not help but have large quantities of gravel incorporated with it, and which may be considered as the Ozark type of the Lafayette formation.

Perhaps the bright red color of the deposits of that period indicates a somewhat warmer climate in the Ozarks than at present.

Post-Lafayette Elevation.

It is a well known fact that the Lafayette period was terminated by an elevation of the continental plateau, at least in the vicinity of the former areas of deposition; and, from the existence of deep submarine continuations of the present river valleys, the elevation appears to have been of continental extent, and to have terminated the Tertiary era and initiated the Quaternary. The Ozark plateau participated in this great epeirogenic movement. The lower cañons or present valleys of the streams are a record of this elevation, and they also show that to a certain extent the elevation has been permanent. It may have originally been greater than now, and during the Columbia epoch was undoubtedly less than now; but the altitude of the Ozarks relative to that of the lands north, east, and south of them, is now greater than it was previous to the post-Lafayette elevation. That is, in addition to the grand epeirogenic movement, there was also a slight orogenic movement, such as has frequently affected the Ozarks.

During the long period of erosion which ensued as the result of the elevation, the streams, whose activity was thus greatly renewed, excavated their new valleys to substantially their present dimensions before the occurrence of the next episode recorded in the Ozark plateau. This excavation meant the removal of, first, the Lafayette deposits in the stream bed; next, the cutting of the underlying solid rock to near baselevel; and then a widening of the valley, by the undermining of its walls, to several times the width of the present streams in the case of the larger valleys, and to many times their width in the minor valleys. This period was undoubtedly long, and meanwhile the first glacial stage or epoch had come and gone, leaving the Kansan drift sheet over the region north and east of the Ozarks. The first interglacial epoch, indicated in the region northward by a long period of subaërial erosion on the previously ice-covered areas, I have been unable to separate from the preceding epochs in those portions of the Ozarks that I have studied. The Kansan glaciation was probably attended by increased precipitation in this region and great erosion, but its effects have been obliterated during subsequent epochs.

The Columbia Formation.

The beds of loess which are found in great thickness along the Missouri valley within the state of Missouri and far to the northwest up that stream, and which also spread out in thin sheets over the lower upland country near by, do not continue into the Ozark region with any large development. Even in the border portions of the uplift the higher upland ridges are free from loess, although no higher than many loess-covered ridges to the north. But along such streams as the Osage and Gasconade rivers, the loess, or rather a loamy deposit resembling loess, extends to a great distance within the Ozark region. It is at first a pretty definitely marked deposit, and forms low terraces, occasionally narrow second bottoms, and even spreads out over the lower ridges of the valleys. As the headwaters of the streams are approached, it becomes less distinct, although still occasionally forming low and imperfect ces; and finally, at an elevation exceeding 1,000 feet the sea, this deposit is generally not present in any liable form. Crossing the watershed and descending on

the south slope of the uplift, we find a precisely similar deposit beginning to appear at intervals along the banks of the streams, growing more and more distinct from the 1,000-foot level down, forming low terraces, and finally, as I have been informed, connecting with the undoubted Columbia deposits along the borders of the Mississippi embayment region.

This deposit is invariably a reddish brown, light-brown, or sometimes buff-colored, sandy clay, nearly free from pebbles except in its lower portion. Fossils occur scattered through the deposit, mostly terrestrial species, generally land snails. It is usually semi-massive, although occasionally well stratified. It occurs on the sides of the lower troughs or present stream valleys as remnants of a formation which once completely filled the valleys to the level of the present uppermost deposits, but which has been almost completely removed. Although falling far short of the Lafayette level, this Columbia level is much above the present highest flood-plain deposits. This formation was of fluvial origin, when the streams ran at a much higher level than they ever succeed in reaching at the present time. The streams, however had already cut their valleys to nearly their present depth, so that their Columbia high level was produced either by excessive rainfall or by a subsidence of the land with the consequent general raising of the water level. The former hypothesis is disposed of by the nature of the deposits, which contain few pebbles and indicate deposition in sluggish currents. Hence it was a raising of the water level consequent on a subsidence of the entire Ozark plateau, which caused a flooding of the streams by great diminution of the drainage gradient, and resulted in the deposition of the Columbia clays in the valleys of the region. The color and texture of the deposit indicate either a small amount of vegetation, insufficient to form a black soil, or a rather rapid gathering of the material from the subsoil clay of the ridges by increasing precipitation of rain or snow. Probably both these conditions were present together, and were caused by the proximity to a vast ice sheet on the north, the Iowan glacial stage or epoch being then at its climax.

The synchronism of these clays with the Columbia deposits of the lower Mississippi and Missouri region seems reasonably certain, for not only is there apparent continuity between

them, but wherever the surface erosion and small gullies are studied it is found to be similar in amount to that on both the Columbia loams of the South, and the Mississippi and Missouri loess deposits of the North. Moreover, the subsidence of the Ozarks, which their phenomena clearly indicate, was undoubtedly contemporaneous with that of all the surrounding regions, and they were merely a portion of the great tract which participated in the epeirogenic movement of depression characterizing the Columbia epoch. The amount of this depression below the present level of the country was variable in the Ozarks. Although perhaps only a few hundred feet in the southern part, it was undoubtedly 400 to 600 feet throughout the central portion, and perhaps 1,000 feet or more at the northeastern corner of the uplift.

In approaching St. Louis from the west on the St. L. & S. F. railroad, the loess or Columbia loam is first observed on the upland ridges in the vicinity of Cuba, at an elevation slightly exceeding 1,000 feet above the sea. Thence to the Mississippi river this loam is found to overspread the surface, excepting where, as on steep hillsides, it has been removed by erosion; and it increases in thickness as lower levels are reached, and especially along the streams, until it connects, after having passed over the Meramec highlands, with the undoubted Mississippi loess at St. Louis. This same bed of clay or loam rests on the eastern slope of the Ozark plateau south from this line, but terminates, as I am informed, at progressively lower levels until it connects with the undoubted marine Columbia deposits of the embayment region. The great depression and partial submergence of the Ozark area here indicated is amply sufficient to account for the permanently flooded but sluggish condition of the streams in the valleys of the central and western portions of the plateau.

Post-Columbia Elevation.

Since the Columbia epoch the valleys of the Ozark region have been gradually assuming their present aspect. First, there was an elevation to approximately the present altitude. The region undoubtedly participated to a certain extent in the minor movements of neighboring regions later in the Glacial period; but these movements were comparatively slight and had little effect on the erosive power of the streams.

As farther north, the streams have done but little more work since the Columbia epoch than to clear out their ancient channels (which they have not yet quite accomplished), and to begin an attack on the solid rock in places, though they have as yet made comparatively little impression on it.

The present altitude of the Ozark region is, I believe, rather above, than below the normal level. Many of the streams abound in rapids, and even some low falls occur that show the streams to be still at work cutting down the bottoms of their beds. In dry weather some small streams disappear entirely and flow below the surface in some cases through crevices and caves in the bed rock of the valley. It is also to be noted that many of the springs flowing from caves have, within a comparatively recent time, cut rapidly to a lower level, and emerge at other places than formerly. Of course, it is the habit of springs to change their place of emergence, but the recent change in the Ozarks is of such a nature as to indicate, I believe, a slight elevation of the region. All the larger caves are Tertiary in age, and are generally quite dry. At a lower level, and much less in size, occur the Quarternary caves. Still lower, and generally well filled by the streams flowing in them, are the caves which now are in the process of formation.

Chronology indicated by the Ozark Valleys.

Studies of the changes, and of the time required for each, in the drift-covered regions, have given a probable mean for post-Columbia time of 50,000 years. Those who have studied the question from phenomena occurring in the coastal plain region want a longer time; but in the Ozarks this time seems sufficiently long, and even more than is necessary, to account for the work which has been done. In the drift regions of the upper Mississippi valley, the time above given is the mean of all estimates made by the writer; and I shall consider it as the most probable approximate length of post-Columbia time.

It is somewhat difficult to compare the amount of erosion in the Ozark valleys since the Lafayette period with that since the Columbia epoch; but, making due allowance for a difference in hardness of material excavated, and also for a probably greater erosive power before than since the Columbia epoch, due partly to difference in gradient, climate and a

longer time of increased precipitation during the Kansan than during the Iowan and later glacial stages, I should say that the ratio of post-Lafayette or Quaternary time to post-Columbia time, as recorded in the Ozarks, is approximately as 6 to 1. In other words, about 300,000 years may have elapsed since the Quaternary valleys of the Ozark region began to be excavated. A comparison of the size of the Quaternary troughs of the region with various valleys and parts of valleys in the drift-covered area, whose age has been calculated from various phenomena connected with them, also brings a probable mean of 300,000 years for the age of the Quaternary valleys of Missouri and Arkansas.

The most reliable estimates of the length of the Quaternary era give it 200,000 years as a minimum and 300,000 years as a maximum. The amount of material removed from the upper troughs or Tertiary valleys of the Ozarks, being on an average twelve times as great as from the Quaternary valleys, would require, under similar condition of erosion, from 2,400,000 to 3,600,000, or, in round numbers, somewhere between two and four millions of years. This agrees well with estimates of the length of the Tertiary era derived from studies of the changes of its molluscan faunas, whereby the probability of the correctness of the figures is confirmed.

Any estimates which might be made of the length of time occupied in forming the Jura-Cretaceous peneplain over what is now the Ozark plateau or mountain region would, owing to a want of knowledge of some of the factors, be of no value whatever, and I will not attempt it. The erosion doubtless amounted to a removal of at least 100 feet, or perhaps several hundreds of feet of strata, mostly sandstone and shale, with a little limestone, from the entire Ozark region.

Conclusion.

We have now endeavored to trace the changes in the topography of the Ozark region, and the history of the erosion of its valleys. We have found no new formation, no earth movement separate in time and quality from those which have affected all the eastern portion of the continent. The Ozarks participated in the movements of elevation and subsidence of the contiguous areas. The best marked epochs or periods of erosion are as well defined here as elsewhere; and the princi-

pal formations of the epochs of partial or complete submergence in contiguous areas are represented at their proper horizons throughout the Ozarks, although in a much less developed condition.

The geological history of the Ozark plateau, since the Jura period, may be summarized as follows:

1. First seen in the Cretaceous period as a low marshy plain, with river systems similar in extent as now,—the Jura-Cretaceous peneplain.

2. Undergoing an elevation of some hundreds of feet, resulting in the excavation of deep broad valleys throughout the border portions of what had become the Ozark plateau,—Tertiary valleys.

3. Probable slight subsidence, resulting in accumulation of a red loamy and gravelly flood-plain deposit in the valleys,—the Lafayette formation.

4. A well marked, and to a certain extent permanent, uplift of the region, resulting in the formation of a new set of valleys in the bottom of the older ones,—Quaternary valleys.

5. Temporary and comparatively rapid, but yet considerable, depression of the area, resulting in the deposition of a loam in the valleys,—the Columbia formation.

6. Re-elevation to approximately the present level, with re-excavation of valleys which had become partially filled by loam,—the present valleys.

A STUDY OF THE BELVIDERE BEDS.

By F. W. Cragin, Colorado Springs, Colo.

The name Belvidere was once employed in the writer's manuscript as a designation for the Comanche Cretaceous shales of the Belvidere district of southern Kansas, but was withheld from publication. These shales were finally named the *Kiowa shales* in volume 5 of Colorado College Studies. The name Kiowa was considered preferable to that of Belvidere because in Kayser-Lake's Text-book of Comparative Geology, now in use in many leading American institutions, the term Belvedere beds is given (page 365) for certain Tertiary sands and gravels of Austria. The proposed name Belvidere differed in spelling by one letter only, and in pronunciation scarcely enough to distinguish it in ordinary conversation

from the established one, Belvedere; and it was feared that it might be too near the older name. But if it be considered that two terms really, even if slightly, different in spelling and applying to deposits widely separated in locality and geological age are in no danger of confusion—a view that seems not unreasonable—then the writer would suggest that the name Belvidere be retained, not in the synonymous term "Belvidere shales," recently substituted for Kiowa shales by Prof. Hill in an article in the American Journal of Science,* but in the term *Belvidere beds*, used in the Plains section of the same article, and including the Cheyenne sandstone and the Kiowa shales, together with No. 5 of the Belvidere section, a terrane that the writer formerly included with the Kiowa shales and that Prof. Hill's recent article makes first a part of the Kiowa shales (*vide ut infra*) and then a part of the Cheyenne sandstone, and which is here recognized as a formation separate from either of these, though related to both, and called the *Champion shell-bed*.

Prof. Hill is not very consistent in his use of the name Belvidere in the article referred to. He first uses the term Belvidere shales in his Black Hills section† as an exact synonym of Kiowa shales as the latter term was originally defined, or in other words so as to include the Champion shell-bed (his No. 4); then defines Belvidere shales‡ so as to *exclude* the Champion shell-bed; and on the same page with the definition, caps this combination by using the term Belvidere beds§ to include the Kiowa shales and the Cheyenne sandstone; and finally he gives ‖ a list of fossils which, he states, the writer has reported from the "Belvidere shales," and here again he includes the Champion shell-beds in these shales, as his listing of the Champion fossils, *Astrocœnia nidiformis*, *Margarita newberryi*, etc., shows. Thus four expressions of views, within the limits of one article, present three conflicting stratigraphic meanings for "Belvidere,"—two meanings for "Belvidere shales" and one for "Belvidere beds." Of the two meanings

*Outlying Areas of the Comanche Series in Kansas, Oklahoma and New Mexico. R. T. Hill: loc. cit., September, 1895.
†Loc. cit., page 208.
‡Loc. cit., page 211.
§In his Plains section.
‖Loc. cit., pages 214, 215.

for "Belvidere shales," one, twice signified by use, makes that term an exact synonym of Kiowa shales as first proposed. The other, a definition proposed but contradicted by use in the same article, makes a few feet of sediments that appear below the main body of the Kiowa shales in one part of their area the excuse for coining a new term, whose meaning is so little and locally different from that of the prior term, Kiowa shales, as to be virtually a synonym of it.

If a geological subdivision must be given a confessedly new name whenever one chooses to pare it off or add to it a little, or has doubt about the original disposal of some small fraction of it, "confusion worse confounded" will increasingly result and finally reign supreme in the science of stratigraphic geology.

Prof. Hill did not think it necessary to find a new name for the Fredericksburg division when he removed the Glen Rose beds from it; and it is therefore hardly needful to find a new name for the Kiowa shales whether the little Champion bed, originally included as a basal and local fraction of the latter, be left in them or removed from them. These two instances merely illustrate the fact that in the majority of cases it is impossible to so define a newly proposed terrane that the definition shall not be liable to future reasonable modification.

If the name Belvidere be considered as retired by the unfortunate double and synonymous use of it above cited, or unavailable because too nearly like the name of the Austrian Belvedere beds, the designation *Walker beds*, referring to Walker's draw, a well known branch of the Medicine Lodge river south of Belvidere, on which exposures of all of the subdivisions of this group are seen, may be used as the collective name for the Cheyenne, Champion and Kiowa. But owing to the prominent part that the vicinity of Belvidere has played in the history of our knowledge of the Comanche rocks of Kansas, it seems fitting (and on other grounds it has been shown not unreasonable) to retain the name Belvidere in some one of the fraternity of stratigraphic senses in which Prof. Hill has used it. For the present, therefore, the term Belvidere beds seems preferable to that of Walker beds as the collective designation for the Cheyenne sandstone, the Champion shell-bed and the Kiowa shales.

Besides the forms listed in this article as belonging to the fauna of the Kiowa shales, the fauna of the Belvidere beds includes the following fourteen fossils not known in the Belvidere district higher than the Champion shell-bed:

Astrocœnia nidiformis Cragin.
Holectypus planatus Roemer.
Serpula championi Crag.
Ostrea roanokensis Crag.
Gryphæa pitcheri Morton, var. *hilli* Crag.
Lima semilævis Crag.
Pinna comancheana Crag.
Limopsis subimbricata Crag.
Astarte pikensis Hill.
Cardium bisolaris Crag.
Homomya alta Roem.
Margarita newberryi Crag.
Turritella seriatim-granulata Roem., var. *marnochi* White.
Turritella (*Lithotrochus*) cf. *humboldtii* Von B.

Altogether there are 78 forms in the known fauna of the Belvidere beds, 13 of which are Vertebrata and 65 Invertebrata. Of these, all of the Vertebrata and 22 species (one-third) of the Invertebrata are peculiar to the Belvidere beds, or at least have been reported from only these and more or less closely related sediments occurring north of the Ouachita mountain-system in Kansas, Oklahoma and New Mexico. The Invertebrata thus peculiar have, with one exception, been described by the writer, and are as follows:

Astrocœnia nidiformis.
Nereis incognita.
Serpula championi.
Plicatula senescens.
Avicula belviderensis.
Limopsis subimbricata.
Nucula catherina.
Remondia ferrissi.
Cardita belviderensis.
Cardium kansasense.
Cardium? mudgei.
Cardium bisolaris.
Tapes belviderensis.
Leptosolen otterensis.
Mactra antiqua.
Margarita marcouana.
Margarita newberryi.
Neritoma marcouana.
Lithotrochus cf. *humboldtii* Von B.
Vanikoro propinqua.
Anchura kiowana.
Petersia medicinensis.

The more important subdivisions of the Belvidere beds, as seen on the Medicine Lodge River valley in the Belvidere district and typically developed in what may be called the Elk-Otter tract, which extends from the heads of South Elk creek near the Barber-Comanche county line to the Otter Creek region in Kiowa county, are given in the following

ELK-OTTER SECTION of the Belvidere Beds:

III. Kiowa shales.
 4. Tucumcari shales (or zone of *Gryphæa tucumcarii.*)
 3. Fullington shales (or zone of *Gryphæa roemeri.*)
 b. Blue Cut shales (or zone of typical and abundant *G. roemeri.*)
 a. Black Hill shale (or Wafer-shale zone.)
II. Champion shell-bed (or zone of *Gryphæa hilli.*)
I. Cheyenne sandstone.
 2. Elk Creek beds.
 b. Stokes sandstone.
 a. Lanphier beds (or Carbopyrite zone.)
 1. Corral sandstone.

These subdivisions may be conveniently discussed in the order in which they are grouped, beginning with the lower.

THE CHEYENNE SANDSTONE.

The *Cheyenne sandstone* is a white to yellowish-gray sandstone, often gaily colored with variations of red and purple in certain horizons, much cross-bedded, locally but not coarsely conglomeratic, and again very fine (almost floury) in certain eastern exposures. It is very porous and its locally phenomenal display of colors, while perhaps in part due, as suggested by the writer in 1885, to chemical reactions following the infiltration of mineral-charged waters from superjacent formations, seems to be largely attributable to oxidations and reactions of substances native to the sandstone itself. At certain localities where the overlying sediments have been Neocene sands and the invading waters siliceous, infiltration has converted lenses of the Cheyenne sandstone into light bluish-gray quartzyte. One of these lenses, now broken down into blocks, covers the sides of a conical hill on the Havard slope of the Havard-South Elk creek divide. To see a reported "blow-out", this hill was visited by the writer in the winter of 1884-'5, and described in No. 3 of the *Bulletin of the Washburn College Laboratory of Natural History*, where the earliest notice of the Cheyenne sandstone appeared. A second lens of this sort is found near South Elk creek not far distant from the former. This is partly undermined and broken into blocks, but a considerable part of the ledge is still *in situ*. The quartzyte is not all perfect. It contains more or less soft spots, consisting of unmetamorphosed or

partially metamorphosed ferruginous sandstone, giving us a glimpse of a stage in the conversion of the sandstone into quartzyte. Some parts of this ledge are traversed with seams of chalcedony.

The springs issuing from the Cheyenne sandstone are usually of more or less distinctly mineral character. Iron, sulphuric acid, gypsum, epsom salts and alum are some of the substances which they commonly hold in solution. In some instances, as in the Blue spring on the now deserted Lanphier claim, the mineral matter imparts to the water a peculiar bluish-white turbidity. A less strongly mineralized spring in the box-cañon head of Cameron draw, a ravine on the farm of Mr. Thomas Cameron, near Belvidere, is probably similar to the Blue spring in mineral character. A qualitative analysis made by Prof. G. H. Failyer, head of the chemical department of the Kansas State Agricultural College, shows that the water of the Cameron spring contains epsom salts, alum and gypsum. That this spring was formerly used by the Indians, is indicated by the now rapidly vanishing hieroglyphics which the latter have carved in the soft Corral sandstone of the adjacent cañon-wall.* A spring on North Elk creek, which was visited a few years since by Mr. William A. Sherrill and the writer and was known to the settlers as Poison spring, issues from the sandstone in a trickling current so heavily laden with white flocculent precipitate as to have the consistency of corn-meal gruel. The mineral matter of the Poison spring, as indicated by the peculiar and astringent taste, is probably in large part alum and epsom salts.

Nodules of the yellow phosphate of iron were discovered in the Cheyenne sandstone by Prof. Failyer as one of the results of a reconnaissance of the Barber-Clark county region, which he made in company with the writer last summer. This discovery makes it seem possible that traces of phosphorous may be found in the waters of some of the springs in this sandstone.

*That the Cameron spring was used as a medicinal spring by the aborigines of the well-named Medicine Lodge River valley, and not merely as an accessible and sheltered camping spot, seems to be indicated by the fact that the north side of this valley is here well supplied from bold springs of the Neocene gravels, with streams of fine water, one of which, Spring creek, enters the bottom-land of the river opposite the mouth of Cameron draw, and is fringed along part of its course with thickets of timber and brush, affording excellent shelter.

In one of the fine, white, floury-appearing exposures of the Cheyenne sandstone, east of the Stokes hill*, and nearly on the Barber-Comanche county line, the writer once excavated a fossil tree-trunk, badly preserved, but showing some of the knots and broken-off branches. It was forty-five feet long, with stump and top missing, and apparently signified a tree of at least twice that hight. Its excurrent habit indicated that it belonged to one of the conifers or their allies, but its microscopic structure was not examined.

Fossil wood is common at certain localities in this sandstone.

The writer obtained the first foliage (*Glyptostrobus gracillimus?*) *in situ* in the Cheyenne sandstone in the fall of 1893, not more than half a mile from the Belvidere railway station; but although he had then known for several years of the discovery of a so-called leaf-bed in either the Carbopyrite or the Wafer-shale zone of the Belvidere beds by coal prospectors, he postponed looking up the locality of the supposed dicotyledons. The announcement of Prof. Hill's discovery has therefore come to the writer with a confirmatory as well as scientific interest.

The Cheyenne sandstone has not been positively identified west of Comanche county, but a remnant of grayish-white and ferruginous sandstone that should perhaps be referred to it, outcrops in the western edge of Little Basin in the western part of Clark county, beneath black lower Cretaceous shale.

In his notice of the discovery of a dicotyledonous flora in the Cheyenne sandstone, in the June number of the American Journal of Science (page 473), Prof. Hill attributes to the writer the opinion that the Cheyenne is the equivalent of the

* This prominent elevation, so conspicuous from points far to the north, east, south and some westerly directions, and which terminates a spur of the divide between Medicine Lodge river and Mule creek, separating branches of North Elk creek from Gant's cañon and Walker's draw, has no other name than "the Black hill," a designation also applied to the hill at Hell's Half Acre, to the hill south of Avilla, etc. But in conversation the writer has found the hill easily recognized by people of the surrounding region when referred to under the name of the former nearest resident, a Mr. Stokes, who lived near the eastern foot of it for several years. The name *Stokes hill* is therefore proposed for it. It is in the southeastern corner of Kiowa county, barely north of the Comanche county line, and about half a mile west of the Barber county line. The natural coral is near the northeastern base of it.

Trinity sandstone, as if the writer were the original and only advocate of such a view; and in the article in the September number of the same journal he seems to have difficulty (page 220) in understanding how the writer could have made such an error as to think of the Cheyenne as being related to the Trinity sands, or the Kiowa shales as being related to the Fredericksburg. Here Prof. Hill fails to give himself due credit.

In Bulletin No. 9 of the Washburn College Laboratory of Natural History (published in February, 1889), the writer gave a preliminary description of the Belvidere section, including as part of the same the Belvidere beds, which he there indicated were related to the Comanche series, without attempting to correlate them more precisely. On page 115 of volume 2 of the 1888 Report of the Arkansas Geological Survey, Prof. Hill referred to that section and alluded to No. 5 of it as representing the Fredericksburg division; and it was there that he was the first to announce that No. 6 (the Cheyenne sandstone) of that section probably represented the Trinity beds.

In later articles the writer followed Prof. Hill in this opinion that the Cheyenne should be referred to the Trinity beds, a view that neither the latter nor the former ever publicly retracted until after the study of the flora of the Cheyenne sandstone by Mr. Knowlton.* But for two or three years past the writer had considered this view as increasingly doubtful and had been inclined to correlate the Cheyenne sandstone with the Paluxy, the terrane immediately underlying the Fredericksburg.

It need not be a matter of surprise if the Paluxy sands should yet yield dicotyledonous remains, since the existence of dicotyledons in Paluxy time cannot be doubted. Prof. Fontaine has described a considerable dicotyledonous flora which flourished on the Atlantic seaboard in an epoch that seems to have been later than earliest Potomac, or than the related early Glen Rose, and which may have been nearly synchronous with the Paluxy.

*In 1891 again, in discussing the sands which he placed below the Glen Rose and called the Trinity sands, Prof. Hill wrote, "In southern Kansas the Cheyenne sandstones have been properly ascribed to this age by Cragin." (Bul. Geol. Soc. Am., vol. 2, page 506.)

Not the discovery of a dicotyledonous flora in the Cheyenne sandstone, but the discovery that this flora, so far as at present known, is of Dakota affinities, indicates that the Cheyenne sediments probably belong to an epoch later than the Paluxy.

But when the Paluxy flora shall become well known, if it prove that it contains no dicotyledons, it must be borne in mind that the absence of the latter may be due to differences of physico-geographic conditions. While early Cretaceous climates were doubtless milder and more uniform than those of recent times, there must have been a *degree* of such climatal differentiation as now obtains. The *Belvidere sea*, as we may call that portion of the older Cretaceous ocean north of the Ouachita mountain-system, was more or less cut off from the great *Texi-Cordilleran ocean* that stretched from the southern shore of Ouachita land across Texas, Mexico and a large part of the Cordilleran region of South America. It was, therefore, perhaps not traversed by warm currents from that ocean. And while, in Cheyenne times, the warm temperate flora of the coming Dakota had already assumed its main features under the developmental influences of the moderate winter and summer seasons that had long prevailed on the great *Nebraskan continent* of northern Kansas, Nebraska, etc., that flora may have been effectively cut off by the Belvidere sea from the flora of Ouachita land, and Ouachita land itself, under the climatic influences of warm currents from the tropical region of the Texi-Cordilleran ocean, may have been occupied by a strictly tropical flora that included no dicotyledons.

Differences of physico-geographic conditions would, on general grounds, appear less probable than differences of time as the cause of the absence of remains of dicotyledons from the Paluxy sands and their presence in the Cheyenne; but it should be noted that a physico-geographic explanation is at least possible. It seems on the whole, however, probable that dicotyledons will yet be found in the Paluxy; and if they be, they will no doubt indicate whether the Cheyenne is approximately synchronous with or later than the Paluxy, the chances being that they will show it to be later, and belonging therefore to a division not earlier than the Fredericksburg.

From its position, immediately underlying the Champion bed, a terrane charged with an essentially Fredericksburg fauna, it seems, on the other hand, impossible to assign the Cheyenne sandstone to a period later than the Fredericksburg.

THE CORRAL SANDSTONE.

The *Corral sandstone* is so named from having a considerable portion of its thickness exposed in the walls of the "Natural corral." The latter is a short box cañon on the Lanphier claim in the southeastern corner of Kiowa county, and has been known under this name by the settlers of this and adjoining counties for many years. It is about thirty feet deep and not only has vertical lateral walls but is also abruptly closed by an equally precipitous head-wall. It has at various times been used as an enclosure for holding stock; and at the time of the writer's most recent visit to it (in August last) the posts of a fence that had closed the lower end of it were still standing.

The thickness of the Corral sandstone is ordinarily thirty to fifty feet. The lower portion of it is white, but the upper is often beautifully variegated with various bright reds mingled with yellow, purple and brown, as at and near the Hell's Half Acre and on the heads of certain south branches of South Elk creek.

The "Chimney rock" and the row of six small pillars which the writer has called (for lack of any other name) the *Cheyenne Brothers*, a short distance down the ravine from Hell's Half Acre, have been carved out of the lower part of this sandstone by erosion. The main part of the once much more prominent Osage rock (formerly called by some the Cheyenne rock), which marks the Cheyenne-Osage battle of the latter part of the sixties, is of this sandstone.

The summit of the Corral sandstone is frequently somewhat more indurated than the rest and tends to form a platform at the base of the softer Lanphier exposures.

THE ELK CREEK BEDS.

The portion of the Cheyenne sandstone situated above the Corral zone may be named the *Elk Creek beds*, from Elk creek, on the heads of which it is finely displayed. These beds are for the most part shaly as well as arenaceous and very varia-

ble. They comprise the sediments from which Prof. Hill has recently reported remains of dicotyledonous leaves, referred by Mr. Knowlton to the following Dakota types:

Rhus uddeni Lesquereux.
Sterculia snowii Lx.
Sassafras mudgei Lx.
Sassafras cretaceum Newberry.
Sassafras sp. nov.
Glyptostrobus gracillimus Lx.
Sequoia sp.

They are separable into two fairly distinct and constant horizons, the Lanphier beds and the Stokes sandstone.

THE LANPHIER BEDS.

These beds, frequently observed but not treated of hitherto by the writer, have recently been described by Prof. Hill, being No. 2 of his Black Hills and Blue Cut sections. They are named from a draw that runs through the Lanphier claim and that may be called the *Lanphier draw*. The latter rises in a basin-like hollow at the foot of Stokes hill, but a short distance south of the Natural corral. Around this hollow the Lanphier beds are well exposed. They are still well developed where they disappear beneath the South Elk-Havard divide, and in the vicinity of the Blue cut, and again on many of the branches of the upper part of Big Mule creek.

They comprise some ten or fifteen feet of incoherent, more or less shaly sands, sometimes passing into shales, often heavily charged with carbonaceous matter, pyrites of iron and selenite crystals, and including numerous fragments of lignite. They are finely exposed at the head of one of the south-side branches of South Elk creek, near the Barber-Comanche county line; and here and on some of the branches of Big Mule creek, especially Indian creek among the latter, they are charged with peculiar lumps of half lignitized and half pyritized wood, which may conveniently be called *carbopyrite*, and fantastic concretions of iron-sandstone and limonite, in which the limonite is pseudomorphic after pyrite. These are of endless shapes. Some look like jug-handles or tubercular crook-neck squashes. Some that attain a diameter of several inches are spheroidal and other shaped aggregations of cubical and modified crystals of limonite after pyrite.

THE STOKES SANDSTONE.

The Lanphier beds pass gradually upward into the similarly leaf-bearing *Stokes sandstone*, a few feet in thickness

(No. 3 of Prof. Hill's Black Hills section). This consists of more constantly arenaceous and consolidated sediments. It is named from one of the localities of its outcrop, the head of what may be called *Stokes draw*, which proceeds from the foot of Stokes Hill near and south of Lanphier draw. At one of the most interesting of the Cheyenne sandstone localities on South Elk creek, where also the Lanphier beds present one of their most remarkable phases, the sandstone of the Stokes horizon, like that of part of the Corral horizon at the same locality, is brilliantly colored, scarlet and other shades of red.

THE CHAMPION SHELL-BED.

Capping the Cheyenne sandstone at Belvidere, its upper surface constituting a somewhat uneven floor beneath the Wafer-shale, by whose ready recession it is sometimes denuded, forming local platforms at the foot of the latter's outcrop, is a thin stratum of gray shell-conglomerate in which the prevailing fossil is the little *Gryphæa hilli* of the north Texas Fredericksburg. This is the *Champion shell-bed*, so named from the fact that it has nowhere yielded so great a variety of fossils as along the branches of what may be called the *Champion draw*. The latter is a hitherto unnamed arroyo of the Medicine Lodge river, that crosses the A. T. & S. F. railway at Belvidere a few rods west of the depot and a short distance below a house built and formerly occupied by Mr. H. B. Champion, to whom the writer is indebted for accommodation on some of his earlier excursions to this interesting district.

In the Belvidere district proper the Champion shell-bed is remarkably persistent, though commonly less than a foot and rarely more than a foot and a half in thickness. Sometimes the bed consists almost wholly of shells cemented into rock by means of arenaceous limestone and calcite, again of a matrix of sand and clay mingled in varying proportion, containing few or many fossils and more or less impregnated with iron-oxide and carbonate and sulphate of lime.

Generally the fossils of the Champion shell-bed are fairly well preserved, but where the impregnation with iron and gypsum is excessive they are sometimes so decomposed as to be scarcely recognizable. In some localities the *Gryphæa hilli* is the only fossil found; but generally it is associated with a

considerable number of invertebrate forms, chiefly molluscan, the fauna of the Champion shell-bed being remarkably large for a stratum so limited in vertical and geographic extent. Thus far the Champion shell-bed has not yielded the remains of any Vertebrata, but the forms of Invertebrata known from it already number thirty-six, or more than half of the entire number known from the lower Cretaceous sediments of Kansas south of the Arkansas river.

FAUNA OF THE CHAMPION SHELL-BED.

****Astroccenia nidiformis* Cragin.
**Holectypus planatus* Roemer.
†*Nereis incognita* Crag.
***Serpula championi* Crag.
†*Ostrea suborata* Shum.
**Ostrea roanokensis* Crag.
**Gryphæa hilli* Crag.
†*Exogyra texana* Roem.
†*Anomia* sp.
†*Plicatula incongrua?* Conrad.
**Lima semilævis* Crag.
†*Vola occidentalis* Con.
†*Avicula belviderensis* Crag.
†*Modiola concentrice-costellata?* Roem.
**Pinna comancheana* Crag.
†*Cucullæa recedens* Crag.
***Limopsis subimbricata* Crag.
†*Trigonia emoryi* Con.
†*Remondia ferrissi* Crag.
†*Cardita belviderensis* Crag.
**Astarte pikensis* Hill.
†*Cardium kansasensis* Meek.
***Cardium bisolaris* Crag.
†*Tapes belviderensis* Crag.
†*Cyprimeria texana* Roem., var. *kiowana* Crag.
†*Pholadomya sancti-sabæ* Roem.
**Homomya alta* Roem.
†*Margarita marcouana* Crag. (*mudgei?* Mk.)
***Margarita newberryi* Crag.
**Turritella seriatim-granulata* Roem., var. *marnochi* White.
***Turritella* (*Lithotrochus*) cf. *humboldti* Von B.
†*Tylostoma tumida* Shum.
†*Natica? cossatotensis* Hill.
†*Anchura kiowana* Crag.
†*Schloenbachia peruviana* Von B.
†*Sphenodiscus belviderensis* Crag.*

Of these 36 forms, the 22 marked with the dagger are, and the 14 marked with single or double asterisk are not at present known to extend from the Champion shell-bed up into the Kiowa shales. The number common to the Champion and the Kiowa is, however, likely to be increased by further explorations more than the number not thus common. Of the forms that are not known to range higher than the Champion, the six marked with the double asterisk are not known outside of the Belvidere district, being strictly peculiar to the Champion shell-bed so far as yet learned. The eight marked with a

*Called *Ammonites belvidereri* in 1890. (Bul. W. C. L. N. H., No. 11.) Small examples illustrated in figures 3, 4 and 5 of plate I in volume XIV of the AMERICAN GEOLOGIST.

single asterisk have not hitherto been seen in the Belvidere district except in the Champion shell-bed; they occur in the North Texas region as follows:

Holectypus planatus was recorded from the Kiowa shales in prefatory remarks of the writer's article on "Vertebrata from the Neocomian of Kansas."* It is a Fredericksburg fossil, being barely known from the Bosque division also, and occurring rarely in the Washita and Denison divisions, the common *Holectypus* of the latter being *H. castilloi* Cotteau.†

Ostrea roanokensis is most common in the Denison division, but occurs also in the Fredericksburg division (in the Comanche Peak limestone) of Tarrant county, Texas.

Typical *Gryphæa hilli* is an abundant characteristic fossil in the Comanche Peak limestone and in the Walnut beds of Tarrant and Williamson counties, Texas.

Lima semilævis was described from specimens obtained in the Denton marls. Soon after it was published, the writer collected it in the Comanche Peak limestone also.

Pinna comancheana, in the typical area, is usually if not always a Fredericksburg fossil. It is common in the lower part of the Comanche Peak limestone of Williamson and Tarrant counties, Texas. In the Tucumcari district of New Mexico it occurs with *Cardita belviderensis* in a terrane that probably belongs to the Kiowa shales.

Astarte pikensis is a species of the Bosque division.

Homomya alta is listed as a fossil of the Glen Rose beds by Prof. Hill in his paper on "Outlying Areas of the Comanche Series, etc."

Of the horizon of *Turritella marnochi* in Texas, Dr. White gives no record more precise than "Cretaceous."

Of the 22 forms common to the Champion shell-beds and the Kiowa shales, 7 are not known south of the Ouachita Paleozoic area, 1 is unknown as to species, and 14 occur in the North Texas region as follows:

Belonging to the Bosque division: *Natica cossatotensis.*

*This article was first published in a separate edition without plates, May 12, 1894, and was republished in volume 5 of Colorado College Studies, with the plates, April 5, 1895.

†The writer having recently examined a large collection of southwestern specimens of *Holectypus* submitted to him by his friend, Mr. Robert W. Goodell, does not now consider *H. charltoni* specifically distinct from *H. castilloi.*

Common in the upper (*Natica pedernalis*, *Cyprina texana* and *C. roemeri*) beds of the Bosque and in (especially the lower and middle parts of) the Fredericksburg: *Exogyra texana.**

Known only in the Fredericksburg: *Nereis incognita*,† *Yola occidentalis*, *Tylostoma tumida* and the typical variety of *Sphenodiscus belviderensis*.

Not recorded from the North Texas area: *Plicatula incongrua*.‡

Almost exclusively a Fredericksburg form, but ranging up into the basal (Duck Creek) part of the Washita: *Schloenbachia peruviana*.

Common to the Bosque?, Fredericksburg and Washita: *Modiola stonewallensis* (=*concentrice-costellata?*).

Common to the Bosque?, Fredericksburg, Washita and Denison: *Ostrea subovata*.

Common to the Fredericksburg and Washita?: *Trigonia emoryi*.

Probably common to the Fredericksburg, Washita and Denison: *Cucullæa recedens*, *Cyprimeria texana*, var. *kiowana* and *Pholadomya sancti-sabæ*.

The fact that *Gryphæa hilli* is strictly confined to the lower and middle Fredericksburg, occurring at Weatherford as low as certain sandy marls which there constitute the base of the Walnut beds and ranging through these beds a considerable distance up into the Comanche Peak limestone proper, indicates that the Champion shell-bed should be referred to the Fredericksburg division and perhaps to a horizon not higher than the middle of that division, a conclusion that is quite consistent with the other data above given, including the mingling which this shell-bed presents of some fossils belonging to divisions respectively higher and lower than the Fredericksburg.

THE KIOWA SHALES.

The *Kiowa shales*, or Comanche shales of the Belvidere beds above the Champion shell-bed, are black, blue and gray argil-

*See also remarks on this species under Kiowa shales.

†The writer has collected this fossil in the Walnut bed at Gabriel Mills, Williamson county, Texas.

‡Recorded in Messrs. Dumble and Cummins' Kent section as occurring in a terrane below the main Fort Worth (*Epiaster elegans*) zone of the "Washita" division (the Kent zone).

laceous shales with beds of arenaceous shale, sandstone and shell-conglomerate as secondary features. They have a maximum thickness of at least 125 feet on the Medicine Lodge river in Kiowa county, and of 150 feet on Bluff creek in Clark county.

They have not been observed by the writer west of the wall that separates Little Basin from Big Basin in the western part of Clark county, where occurs a remnant, much reduced in thickness by erosion and well exposed only in the Little Basin side of that wall. In the walls of Big Basin generally, the Loup Fork Tertiary rests directly upon the Big Basin sandstone, or with only local, well nigh vanished remnants of the Belvidere beds between it and the latter. On the lower part of Crooked creek, in Meade county, the Kiowa shales are lacking, fresh-water Neocene sediments there resting upon a somewhat degraded surface of the Kiger. It is possible that a remnant of these shales may be found a little west of Big Basin, on upper-middle drainage of Big Sandy creek, only the head of one western branch of which has been seen by the writer.

They occur at Mount Tucumcari, New Mexico; at Kent and many other localities in Texas, including probably the vicinity of Tascosa in the "Panhandle:" in the Choctaw Nation, and in Oklahoma: the Oklahoma and Panhandle occurrences being small remnants.

The following list excludes a number of erroneous identifications reported in earlier writings and some merely manuscript names, but includes all of the forms that the writer now recognizes as belonging to the

FAUNA OF THE KIOWA SHALES.

Invertebrata.—51 Species.

Enallaster sp. (Fragments: fide Clark per Stanton.)
Nereis incognita Cragin.
Polyzoan: gen. et sp. ind.
Lingula sp.
Ostrea franklini Coquand.
Ostrea quadruplicata Shumard.
Ostrea subovata Shum.
Gryphæa pitcheri Morton, var. *roemeri* Marcou.
Cardita belviderensis Crag.
Cardium kansasense Meek.
Cardium ? mudgei Crag.
Protocardium texanum Con.
Roudairia securiformis Crag.
Tapes belviderensis Crag.
Cyprimeria texana Roem., var. *kiowana* Crag.
Tellina ? sp.
Leptosolen otterensis Crag.

Gryphæa pitcheri var. *tucumcarii* Marcou.
Exogyra texana Roemer.
Anomia sp.
Plicatula incongrua ? Conrad.
Plicatula senescens Crag.
Pecten inconspicuus ? Crag.
Vola (Neithea) occidentalis Con.
Avicula belviderensis Crag.
Avicula leveretti Crag.
Inoceramus comancheanus Crag.
Modiola concentrice-costellata ? R.
Lithophagus sp. nov. (Fide Stanton.)
Cucullæa recedens Crag.
Nucula catherina Crag.
Leda sp. (Fide Stanton.)
Yoldia microdonta Meek.
Trigonia emoryi Con.
Remondia ferrissi Crag.
Pholadomya sancti-sabæ Roem.
Mactra antiqua Crag.
Corbula crassicostata Crag.
Dentalium sp.
Margarita marcouana Cragin. (*mudgeana* ? Mk.)
Trochus texanus Roem.
Neritoma marcouana Crag.
Turritella seriatim-granulata Roem., var. *kansasensis* Meek.
Turritella (Mesalia) ventrivoluta Crag.
Vanikoro propinqua Crag.
Tylostoma tumida Shum.
Natica ? cossatotensis Hill.
Anchura kiowana Crag.
Petersia medicinensis Crag.
Schloenbachia peruviana Von B.
Sphenodiscus belviderensis Crag.

Vertebrata.—13 Species.

Lamna sp. (Like *L. occidentalis* Leidy; fide Williston.)
Lamna ? quinquelateralis Crag.
Hybodus clarkensis Crag.
Carlodus brownii Cope.
Mesodon ? abrasus Crag.
Uranoplosus arctatus Cope.
Uranoplosus flectidens Cope.
Teleost. (Vertebra like that of *Portheus;* fide Williston.)
Plesiosaurus mudgei Crag.
Cimoliosaurus sp. nov. (Fide Williston.)
Plesiochelys belviderensis Crag.
Turtle, size of *Protostega.* (Fide Williston.)
Hyposaurus ? sp. (Fide Williston.)

The Invertebrata common to the Kiowa shales and to the Comanche of that portion of Texas and Arkansas in which the divisions proposed for this series have been worked out and are especially applicable may, as to their occurrence in that typical tract, be analyzed as follows:

The genus *Enallaster* is most abundant in the Fredericksburg division, but is not very uncommon in the Choctaw and Grayson terranes of the Denison.

Ostrea franklini, in the Texas-Arkansas region, chiefly abounds in the Bosque division, but ranges at least as high as the Choctaw limestone. Having given a great deal of study to this species as it presents itself in Texas and Kansas, and having recently reëxamined the question of the identity of the little conglomerate-building *Ostrea* so common in the Blue Cut

and Tucumcari zones of the Kiowa shales, giving particular attention to the characters of beaks, cartilage-pit and adductor scar, the writer is compelled to differ from Mr. Stanton when he says that "this [the Kiowa shales] species is probably a new form," finding no constant nor nearly constant differences from *Ostrea franklini*.

Ostrea quadruplicata, which has been found in the upper part of the Kiowa shales of Clark county and in the Mentor beds of Saline and Ellsworth* counties, Kansas, has not been reported lower than the upper part of the Washita within the typical area here considered. It has been recorded as occurring in a limestone (the Kent bed) a few feet above one containing *Gryphæa tucumcarii* and *Schloenbachia leonensis* and underlying the zone of *Epiaster elegans* and *Holaster simplex* (Fort Worth zone) in the eastern part of El Paso county, Texas, by Messrs. Dumble and Cummins in their interesting Kent section, published in the AMERICAN GEOLOGIST of November, 1893.

Ostrea subovata occurs in most of the terranes of the Fredericksburg, Washita, and Denison divisions, being found at least as low as the summit of the Bosque and as high as the Choctaw limestone.

Gryphæa roemeri is abundant in the Kiamitia and ranges up into the Duck Creek.

Gryphæa tucumcarii is recorded by Prof. Hill as occurring on the "plains of the Kiamitia," but the horizon of its occurrence there is not given. By Messrs. Dumble and Cummins it is recorded as occurring below the Kent bed (*vide ut infra*) at Kent, Texas, associated with *Schloenbachia peruviana* and *S. leonensis*, a little above the lowest occurrence of the latter.

Exogyra texana, in the typical area, is chiefly a Fredericksburg form. It is also common there in the upper Glen Rose beds of the Bosque division, but it does not occur in the Washita division within that area so far as known. Nor has

*For his knowledge of the occurrence of this fossil in Ellsworth county the writer is indebted to specimens in the museum of the State University of Kansas, collected by the late Judge E. P. West. These specimens were labeled as having come from the base of the Dakota on Alum creek: but as the Mentor terrane was then supposed to constitute the base of the Dakota, there can be scarcely a doubt as to the specimens having been found in the Mentor beds.

it been recorded from rocks of that division anywhere save (? below the zone of *Epiaster elegans*) in a single remote southwestern locality, the western part of El Paso county, Texas.

Plicatula incongrua has no record in the typical area. It has been recorded by Messrs. Dumble and Cummins at Kent from an *Ostrea quadruplicata* zone (the Kent bed) below the horizon of *Holaster simplex* and *Epiaster elegans* and above the *Gryphæa tucumcarii* limestone.

Pecten inconspicuus. Mr. Stanton records from the Kiowa shales a *Pecten* which he says is "a small smooth form like one that occurs in the Paw Paw beds of Denison." This is probably *Pecten inconspicuus*, the only known species that answers to Mr. Stanton's description of the Kiowa form. After the description of this species was published the writer obtained a number of specimens indicating that this *Pecten*, though always very small, attains dimensions considerably larger than those that were given for it. The largest of these specimens has a hight of over thirteen millimeters. The ears are of moderately large and subequal size, though quite different in shape, and are both ornamented with numerous, subequal, sharply-raised lines on the border by which they spring from the body of the valve.

Vola occidentalis is the common *Vola* of the Fredericksburg. The name *Vola fredericksburgensis* was proposed for this species inadvertently and is here withdrawn. The species was correctly referred to *occidentalis* and to the subgenus *Neithea* in the writer's earlier papers.

Avicula leveretti is mentioned by Prof. Hill as if it did not occur below the Kiamitia. In the writer's original account of this species it was recorded from the Kiamitia and from the *Exogyra texana* bed, or basal Fredericksburg. It is not known to occur above the Kiamitia and is one of the forms that shows relationship of the Kiamitia to the Fredericksburg.

Inoceramus comancheanus is a fossil of the Duck Creek limestone, the basal member of the Washita.

Modiola concentrice-costellata? The shell here indicated is the writer's *M. stonewallensis*. It is common to the Fredericksburg and Washita. It has not been recorded from the Denison division, but occurs in the highest, or Denton, terrane of

the Washita. Some of the rocks in which it occurs in northwestern Texas should possibly be referred to the upper portion of the Bosque division. The description and illustrations of the little round-ribbed shell called *Modiola concentricecostellata* in Roemer's *Kreidebildungen* is, on stratigraphic grounds, suspected to have been based on small and poorly preserved specimens of this species. But only the fact that the types of Dr. Roemer's species came apparently from within the stratigraphic range of *M. stonewallensis* would ever lead one to suspect this, so widely different is the character of the ribs, as illustrated, from the concentric ornamentation of *Modiola stonewallensis*.

Cucullaea recedens is common to the Fredericksburg and Denison divisions. The writer has collected it in the Walnut and Comanche Peak terranes of the former and in the Choctaw terrane of the latter.

Nucula catherina is reported by Prof. Hill as having been "identified in the Washita division of the North Texas region." It would be interesting to know what terrane and locality of that division yield it, as it is a fossil common in both the Kiowa shales and the Mentor beds. If the terrane that yields it in the North Texas region be the Kiamitia, which Prof. Hill calls a Washita and Mr. Taff calls a Fredericksburg terrane, its "Washita" occurrence means simply occurrence in a group of sediments intermediate between Fredericksburg and Washita, the Kiowa group, which is about equally related to the Fredericksburg and to the Washita; but if it be one of the Denison division, it occurs above the true Washita.

Yoldia microdonta in northern Texas, is a Denison division fossil, being common in the Pawpaw beds. In central Kansas, it is a fossil of the Mentor beds.

Trigonia emoryi, unlike the Denton marl species, *T. clavigera*, is probably common to the Fredericksburg and Washita, and not improbably to the Denison also. It was observed by the writer in limestone of the Walnut zone of the Fredericksburg in 1890 when, in company with Prof. Hill, he was leaving Weatherford enroute for Granbury. The species is extremely common in some localities in the Walnut clays of the Fredericksburg. Twenty-five well preserved specimens of it from these clays are before the writer, which were his share

of a collection made by Prof. O. C. Charlton and himself in passing a single hill-slope when approaching Walnut Springs from Iredell. These specimens are of the typical phase shown in Conrad's original illustration, having the ribs ornamented with low, narrowly compressed tubercles or cross-folds. This type of ornamentation is quite different from that displayed by the *T. clavigera*. In the latter, which occurs abundantly and beautifully preserved in the Denton marls of Cooke county, Texas, and the Choctaw Nation, the ribs bear short, erect, triangularly-stalked, clavate, or tubercular-ended spines. No one having well-preserved Trigonias from these two terranes before him, could confuse them. There occur, however, in the Mentor beds of Saline county, Kansas, numerous molds of a *Trigonia* that the writer has elsewhere referred to *T. clavigera*, but which are more or less intermediate, so that it is not improbable that *T. clavigera* will prove to be a variety, though, as typically developed in the Denton marls, it would at least be a very strongly marked variety of *T. emoryi*. The record of *T. clavigera* for the Kiowa shales is here withdrawn, as the specimens on which it was given were poorly preserved and the specific determination was based largely on stratigraphic considerations.

Cardium kansasense, which Prof. Hill calls a Dakota species, stating (loc. cit., page 223) that Mr. Stanton fails to find it in the Hill collection from the Kiowa shales, is one of the commonest fossils in the shell-limestone of the Blue Cut shales and occurs also in the Champion shell-bed, but in the latter has been found only in Champion draw and in moderate number. It does not occur in the Dakota, but is an abundant element of the fauna of the Mentor beds, from which came Mr. Meek's types of the species. Poorly preserved specimens, showing the same misleading aspect of the ornamentation as is shown in the imperfect types figured by Mr. Meek, are not uncommon.

The Kiowa shales fossil that the writer calls *Protocardium texanum*, which is probably the same that Mr. Stanton has identified from these shales as *multistriatum*, is in reality somewhat intermediate in character between these two species. It differs widely from equal-sized specimens of *P. multistriatum* from the Sierra Blanca mountains of El

Bass county, Texas, and from larger specimens of the same from the Comanche Peak limestone of central Texas. The Texas specimens have the concentric raised lines and striæ crowded over the entire hight of the valves, while the concentric striæ on the lower part of the valves of the Kiowa shells are separated by ribs of considerable breadth.

Roudairia securiformis (formerly called *Trigonia securiformis*), of which *Roudairia quadrans* is a synonym, is a species of the Comanche Peak limestone.

The shell that the writer describes elsewhere as *Cyprimeria texana*, var. *kiowana*, is probably not different from the form so abundantly represented by casts in the Comanche Peak limestone, agreeing with these and differing from the casts of the typical *Cyprimeria texana* (which occur in a horizon between the *Exogyra texana* bed of the Fredericksburg and the principal *Exogyra texana* bed of the Bosque) in size and apparently, though perhaps not constantly, in convexity. It is probable that most of the specimens of *Cyprimeria* from the upper divisions of the Comanche also belong to the variety, *kiowana*.

Pholadomya sancti-saba ranges from the Fredericksburg to the Denison division. It is the small form, like that of the Kiamitia clay of Indian Territory, rather than the large, coarsely ornamented one of the Denison beds, that occurs in the Kiowa shales.

The *Corbula crassicostata* of the Kiowa shales is probably the same *Corbula* that is common in the Denison division, as the writer noted under the original description of the species. It is one of the most abundant of the fossils of the Pawpaw beds.

Trochus texanus in Texas is known only from the Barton Creek limestone of the Fredericksburg division.

The originally described variety of *Turritella seriatim-granulata* is a small phase that presents one extreme of size in this species and is characteristic of the upper Glen Rose beds at Fredericksburg. The commonest and, as to size, the central variety of the species, var. *kiowaensis*, found so profusely and in so excellent preservation in the Kiowa shales (especially in the lower part of the Blue Cut zone and in the Mentor beds) is the same that occurs in the Comanche Peak

limestone and in the Washita and Denison divisions in Texas and Indian Territory. The large and coarsely ornamented extreme of the species, which is the prevailing phase in the Champion bed, does not seem to differ from that which, from some unknown horizon of the (probably Comanche) Cretaceous, Dr. White has described under the name *marnochi*, and which is also approached by some of the largest specimens from the Pawpaw beds.

Mesalia ventriroluta has been found in northern Texas, but only in "drift."

Tylostoma tumida is one of the characteristic and profusely abundant fossils of the Comanche Peak limestone.

Natica? cossatotensis has hitherto been reported only from the Bosque division.

Schloenbachia peruviana bears a somewhat closer relation to the Fredericksburg division than *S. leonensis* does to the Washita. It is common in the Walnut and Comanche Peak terranes of the Fredericksburg and ranges up through the Kiamitia into the Duck Creek. *S. leonensis*, on the contrary, rarely if ever descends into the Kiamitia in the North Texas region, the common *Schloenbachia* of the Kiamitia there being the Fredericksburg species, *S. peruviana*.

The specimens of *Sphenodiscus belvidercnsis* from the Kiowa shales do not seem to differ materially in sutural pattern from specimens of that species from the Comanche Peak limestone of Texas.

THE FULLINGTON SHALES.

The *Fullington shales*, named after the great Fullington ranch at Belvidere, on which they have most extensive outcrops, include the lower and major part of the Kiowa shales. They are not sharply separated from the overlying Tucumcari shales either lithologically or paleontologically. They include that portion of the Kiowa shales in which the *Gryphæa* is Marcou's *G. roemeri*.

At Belvidere they are separable into two principal subdivisions, the lower of which is

THE BLACK HILL SHALE.

This terrane was named and briefly characterized by the writer in 1885, in his "Notes on the Geology of Southern Kansas." The name was derived from the Black hill adjoining

Hell's Half Acre on Elk creek in Comanche county. The terrane consists of a bed of black carbonaceous clay-shale fifteen or twenty feet thick, resting upon the Champion shell-bed and characterized by a peculiar method of disintegration, breaking down under the weather into small, flat and thin, sharp-edged spalls resembling wafers, a peculiarity that has suggested for this shale the name of *Wafer-shale*.

The Black Hill shale is for the most part barren of well-preserved fossils. In places it has in its upper part a bed of ill-shapen *Gryphæa*, some of the examples of which evidently are deformed *G. corneri*, while some others possibly should be considered as representing *G. hilli*, together with *Ostrea subovata* and *Exogyra texana*. Elsewhere its upper portion yields crushed or entire shells and casts of *Modiola concentrico-costellata?* (*M. stonewallensis*), *Tapes belviderensis*, reptilian bones (*Plesiochelys belviderensis*) and other fossils, most of which are abundant and often finely preserved in the somewhat higher zone that is transitional from the Wafer-shale to the upper subdivision of the Fullington shales, viz.:

THE BLUE CUT SHALES.

These are named from "the Blue cut," a deep railway-cut a few miles south-southwest of Belvidere, the same from which the writer's Blue Cut section was named. The Blue cut, however, in the first instance, owes to the color of these shales the name by which it is known to the railway employees and inhabitants of the Belvidere district. They consist of alternations of blue-back and gray argillaceous shales with minor beds of sandy shale, ferruginous sandstone and shell limestone. In the latter the shells differ from those of the Champion shell-bed in character of preservation and in color, the shells of the Champion shell-bed being largely calcite and gray in color, while those of the Blue Cut shell-beds (except the gray to glossy purple-red *Ostreidæ* and the sometimes blackish *Veritidæ*) nearly all consist of ferruginous yellow limestone. The transitional Black Hill-Blue Cut horizon, in certain localities, yields the smaller and generally rarer shells more abundantly than other horizons. In the thicker shell-beds, a little above the base of the terrane, *Cyprimeria texana* var. *kiowana* is conspicuous on account of its size as well as its abundance, some of the beds having their major portion built up of these

shells, which are, however, associated with other species, among which two of the most constantly abundant are *Cardium kansasense* and *Turritella seriatim-granulata* var. *kansasensis*.

The occurrence of the Duck Creek shell, *Inoceramus comancheanus*, in these shales is noteworthy.

All of the vertebrate and nearly all of the invertebrate fossils listed from the Kiowa shales have been found in the Fullington beds, including the upper portion of the Black Hill, and all, but especially the lower part, of the Blue Cut shales.

The lower part of these shales presents locally a "fish-bed" horizon in which occurs *Lingula*, associated with numerous small shark's teeth and fragments of teeth and spines, recalling the so-called "fish-bed" of the Benton in its composition.

Fossils generally are neither so abundant nor so well preserved in the upper, usually lighter-colored portion of the Blue Cut shales as in the lower portion. But to this rule we see exceptions in *Ostrea franklini*, *Gryphæa vomeri* and *Exogyra texana*, the first of which occurs in solid ledges with either of the two latter, or other shells as intruders, and the second of which occurs also finely petrified in the soft shale and sometimes in such numbers as to constitute loose beds, though rarely rock-ledges like those of *O. franklini*. *Schlœnbachia peruviana*, *Cyprimeria kiowana*, and indeed almost any of the fossils that are abundant in lower horizons of the Blue Cut shales, occur occasionally, and in more westerly localities even commonly, though rarely well preserved, in the upper horizons also.

THE TUCUMCARI SHALES.

The shells of the genus *Gryphæa* increase in size as found in successively higher horizons of the Belvidere beds from the appearance of the genus in the Champion shell-bed to its disappearance just below the base of the leaf-bearing *Reeder* (Dakota?) sandstone which surmounts the Kiowa shales in the upper valley of the Medicine Lodge river near the post-office at Reeder. The largest examples are found in the upper Kiowa shales of the Otter Creek district. Some of these seem most nearly related to *Gryphæa vomeri*; but others clearly belong to *G. tucumcarii*, particularly to that phase of the latter that Mr. Jules Marcou has called *G. dilatata*; while others still represent various intermediate forms between the

two. To the zone characterized in part by this variable *G. tucumcarii*, the name *Tucumcari shales* is here given, after Mount Tucumcari, New Mexico, where the zone of *Gryphæa tucumcarii* was originally discovered by Mr. Jules Marcou.

These shales are well developed in the vicinity of Otter creek, on Thompson creek, and on heads of several smaller branches of the Medicine Lodge river.

They are chiefly clay-shales, and lighter hued, as a whole, than the Blue Cut shales, which graduate insensibly into them. At their summit, they frequently contain bands and concretions of clay-ironstone, in the succession of which, premonitory of the immense aggregations of concretions that constitute certain parts of the Reeder sandstone of Kiowa and Clark counties, the *Gryphæa*, now in its maximum size, is lost sight of, becoming scarcer and more poorly preserved before wholly disappearing.

CORRELATION.

An order of horizons, incomplete, but roughly resembling that seen in the Elk-Otter tract, is found in the western extension of the Belvidere beds: but the differentiation, whether lithological or paleontological, is there less clearly expressed. To just what extent the various members of the Elk-Otter section are present, and where present can be recognized, west of the Medicine Lodge River valley, is still to be ascertained.

The relation of the recently described Mentor beds to the upper part of the Kiowa shales is evidently close, but a precise understanding of it at present seems difficult owing to the apparent absence of *Gryphæa* from Comanche sediments north of the Arkansas river. But the writer would here state that, in the light thus far obtained, it seems to him that the previously supposed relationship of the Mentor to the Denison is probably more apparent than real and should be largely ascribed to similarity of physico-geographic conditions.

The Blue Cut shales, and at least the upper part of the Black Hill shale, should evidently be correlated approximately with the Kiamitia, as has been done by Mr. Stanton, the Kiamitia being about equally related to the Fredericksburg and the Washita.

The Tucumcari and the Mentor represent somewhat later than Kiamitia sedimentation, but both are probably earlier

than the Fort Worth (*Epiaster elegans*) zone of the Washita. Messrs. Dumble and Cummins' section indicates that the Tucumcari zone belongs to a position a little below that of the *Ostrea quadruplicata* zone which they describe as below that of *Epiaster elegans* and which, to distinguish it from the *quadruplicata*-bearing horizons *above* the Fort Worth zone may be called the *Kent* bed. This Kent bed occupies a position near that of the north Texas Duck Creek, and the Mentor terrane is perhaps not far, in horizon, from the Kent.

The paleontological aspect of the mollusk-bearing beds of the Tucumcari district, as portrayed by Prof. Hill, is such as to show that a portion of those beds must be referred to the Kiowa shales. But too little has yet been published as to the stratigraphic range of the fossils of the Tucumcari district to warrant the conclusion that all of those beds should be so referred. The Tucumcari zone of the Kiowa is there finely developed.

Turbinolia texana, which Prof. Hill gives as one of the Tucumcari district fossils "peculiar to and characteristic of the Washita division," may occur in the Washita, but is certainly not confined to it. It is, on the contrary, one of the common fossils of the Comanche Peak limestone in the typical North Texas region. In the outlying El Paso and Tucumcari districts it very likely occurs in the inter-Fredericksburg-Washita group of sediments.

The evidence taken altogether seems to point to the conclusion that the Kiowa shales of Kansas, the Kiamitia and Tucumcari shales of Indian Territory, the limestones 5b and 5c of Messrs. Dumble and Cummins' Kent section, and a portion of the mollusk-bearing beds of the Tucumcari district, represent a group of sediments intermediate between the Fredericksburg and the Washita divisions, and one which, as the meeting ground of the faunas of these two divisions, cannot satisfactorily (though it may arbitrarily) be referred to either.

CLASSIFICATION OF COMANCHE TERRANES.

A brief statement of the classification adopted by the writer for the sediments of the Comanche series is added in conclusion, to indicate the basis of the stratigraphic references in this article.

The Comanche series naturally resolves itself into terranes and horizons the character and degree of whose differentiation vary with the locality: but the grouping of these terranes into divisions is arbitrary and only approximately expresses natural relationships. The so-called divisions are usually connected by more or less important intermediate groups of sediments not properly referable to either. Where such a connecting group is of considerable thickness and wide geographic extent, and is itself separable into minor subdivisions, such a group is probably most naturally disposed of by considering it a division. The Kiowa shales, including the Kiamitia and the Tucumcari (or, in the Belvidere district of Kansas, the Black Hill, the Blue Cut and the Tucumcari) present these conditions and are therefore considered as constituting the *Kiowa division.*

The Tucumcari terrane is not positively known to occur south of the Ouachita mountains, but Prof. Hill's record of the occurrence of *Gryphaea tucumcarii* near Goodland, Indian Territory, suggests the probability that its horizon may be distinguishable in the Choctaw Nation.

The writer believes that the two groups of Shumard, the Washita limestone (including the Duck Creek, Fort Worth and Denton terranes) and the *Arietina* (for which the geographic name Denison is preferable, and which includes the North Denison, Pawpaw, Choctaw and Grayson) represent divisions as natural as any, and that the sediments of the Texas-Arkansas Comanche should be grouped in divisions as follows, the oldest unpreöccupied, reasonably brief*, stratigraphic names of geographic derivation being in all cases given the preference.

Comanche Series.

DIVISIONS.	TERRANES.
Shoal Creek (of Hill).	Not subdivided.
Denison (of Hill).	Grayson (of Cragin).
	Choctaw (of Cragin).
(Arietina, of Shumard.)	Pawpaw (of Hill).
	North Denison (of Hill).

*Stratigraphic terms, the geographic part of which consists of more than two words, are considered inadmissable. Hence the term, Trinity sandstone, takes precedence over the older one, Lower Cross Timber sandstone.

	Denton (of Taff).
Washita (of Shumard).	Fort Worth (of Hill).
	Duck Creek (of Hill).
Kiowa (of Cragin)	Tucumcari (of Cragin).
	Kiamitia (of Hill).
	Barton Creek (of Cragin). (Caprina and Caprotina, of Shumard.)
Fredericksburg (of Hill).	Comanche Peak (of Shumard).
	Walnut (of Hill). (Exogyra texana, of Shumard.)
	Paluxy (of Taff).
Bosque (of Taff).	Glen Rose (of Hill).
	Trinity (of Hill.)

The *Barton limestone* includes the Caprina limestone and the Caprotina limestone of Dr. Shumard. It is named from Barton creek, on which, near Austin, Texas, it has its finest paleontological expression. It is on Barton creek that Mr. George Stolley obtained from this limestone the collection of beautiful calcite fossils that constituted the basis of Dr. Roemer's final contribution to Texas paleontology.*

The Washita division, as here defined and as used in this paper, includes a group nearly equivalent to that which Dr. Shumard defined as "the *Washita* limestone," differing from it only in excluding the Tucumcari terrane. Most divisions are arbitrary, or only in part natural; and Dr. Shumard's *Washita*, with the slight modification here adopted, is as natural as any of the divisions of the Comanche series hitherto proposed.

Dr. Shumard's Arietina (for which Prof. Hill's geographically derived name, *Denison*, is properly retained) is of equal importance with the Washita, and is quite too well differentiated and large a group of sediments to be swallowed up by the name of the latter. If it be needful to sometimes use a collective name for the Washita and the Denison, an unpreöccupied name must be found; and for such use the name *Gainesville*, from the north Texas town of that name, which practically marks the boundary between the Washita and the Denison, is appropriate.

*Ueber eine durch die Häufigkeit Hippuriten artiger Chamiden ausgezeichnete Fauna der oberturonen Kreide von Texas. Ferdinand Roemer. In Paleontologische Abhandlungen von Dames und Kayser, vierter Band, Heft 4. Berlin, 1888.

EDITORIAL COMMENT.

THE HEIM-CAPELLINI INCIDENT IN THE INTERNATIONAL GEOLOGICAL CONGRESS AT ZURICH.

An answer to a letter addressed by the undersigned to Prof. Capellini contains the following:

"The first prize, awarded to M. Heim was 2,000 francs. The second was awarded to M. A. Karpinski, 1,200 francs. The third, 800 francs, was awarded to M. Maillard. Heim had had the illustrations and manuscript in 1881-1882. He had returned them with the greatest punctuality." * * [The Congress of Bologna was held from Monday, Sept. 26, 1881, to Sunday, Oct. 2, 1881. P. F.] * * "I have his card acknowledging the receipt of manuscript again dated Dec. 16, 1891. He added 'I thank you very much for the trouble you have taken to loan it to me.' The manuscript was finally returned March 11, 1895. Dec. 16, 1891, to March, 1895, makes three years and three months."

The documents were therefore borrowed twice, but in the statement which I took down as it was made, the fact of the first return was accidentally omitted. Although I cannot consider myself responsible for the error, I regret having been led into it and now publicly correct it. Prof. Heim did not borrow and retain the manuscript and illustrations of his first prize essay before the International Congress of Bologna for thirteen years, but only for three years and three months.

I have already acknowledged my error in stating that he received only 1,200 instead of 2,000 francs, an error which is the less excusable because the facts are clearly set forth on page 87 of the Bologna volume. PERSIFOR FRAZER.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geology of the Green Mountains in Massachusetts. By RAPHAEL PUMPELLY, J. E. WOLFF, and T. NELSON DALE. (U. S. Geological Survey, Monograph XXIII, pp. xiv, 206; with 23 plates and 79 figures in the text: Washington, 1894. Price, $1.30.) The gneisses, conglomerates, and crystalline schists of the Green Mountain range are shown to be of Cambrian and Lower Silurian age, ranging from the Olenellus zone upward to the Hudson River. In Greylock, the highest mountain of Massachusetts, rising to 3,505 feet above the sea, thick formations of

limestone alternate with the schists, the section in descending order being the Greylock schist, the Bellowspipe limestone, the Berkshire schist, the Stockbridge limestone, quartzite conglomerate, and the Stamford gneiss. The series has an aggregate thickness of 5,000 feet or more. In the Hoosac range, a few miles distant on the east, the corresponding section has no limestone; and the Greylock series above the conglomerate is represented there by the Rowe and Hoosac schists.

Summing up the geologic history of this mountain belt, Prof. Pumpelly writes: "The results of the survey in northwestern Massachusetts lead to the supposition that the central or main ridge was in pre-Cambrian time outlined as a mountain range of highly crystalline rocks on the western border of an area of dry land. During long exposure to the action of atmospheric agencies and of the products of vegetable decay, the rocks of this region had become decomposed at the surface and disintegrated at depths. The breaching action along the advancing shore line of the Cambrian sea found ready prepared the materials which the water assorted and distributed to form the great sheet of Cambrian rocks. While these deposits of detritus were accumulating over the shallow areas, the materials for the future limestone were gathering offshore to the west. As the positive movement deepened the water shoreward, the calcareous materials accumulated above the earlier detrital beds, so that we may imagine that, while the later beds of the Cambrian were being made of sand and gravel in shallow water, the lower beds of the great limestone were being deposited offshore. Later, with a change of some kind in the conditions, there came the deposit of finer material over the previously shallow region, while the accumulation of limestone, with Lower Silurian organisms, still continued offshore. Still later, by another change in the conditions, the deposit of finer detrital material extended far to seaward, covering everywhere the limestone accumulations."

Very thorough structural and petrographic studies of Hoosac mountain and adjacent territory are presented by Mr. Wolff in pages 35-118, plates IV-XI; and of Greylock mountain by Mr. Dale in pages 119-196, with plates XII-XXIII. Metamorphism has nearly everywhere produced cleavage foliation, which commonly is far more conspicuous than the vestiges of the original stratification. On a grand scale the rocks lie in a series of meridional folds; and often hand specimens of the schists have minute and even microscopic folds and faults. Referring to the extreme complexity of these altered and foliated formations, in which the sedimentary stratigraphy is usually very obscure, Dr. Wolff remarks: "The gneisses of the Green mountains are just as susceptible to stratigraphic investigation as the unaltered sediments of the Appalachians, but the problem is much more difficult owing to the secondary structures produced by metamorphism."

Following his description of the geology of Mt. Greylock, Mr. Dale adds a short discussion of the influence of the geologic structure in determining the present topographic contour.

It is hoped that the detailed work here published will serve as a bridge leading toward the determination of the stratigraphy and age of the similarly metamorphosed and crystalline rocks which form nearly the whole area of the New England states; since the western border of the Green and Taconic mountains is the boundary between those rocks and the unaltered Paleozoic series which occupies the greater part of New York and of the Appalachian mountain belt thence southward.

W. U.

Handbook and Catalogue of the Meteorite Collection. By O. C. Farrington, Ph. D. (Publications of the Field Columbian Museum, Geol. Series, vol. 1, no. 1. Chicago, Aug., 1895.) This meteorite collection, now carefully catalogued for future use, ranks amongst the largest in the world. It is made up of original purchases from the Ward Science Establishment, of Rochester, N. Y., at the time of the World's Columbian Exposition, where these specimens were on exhibition by Prof. Ward, and of later purchases from Mr. Geo. F. Kunz. They comprise many of the largest and most valuable meteorites fallen in American localities, as well as large representatives of meteorites from nearly all parts of the world. With the casts, which number about fifty of the other important meteorites, made by Ward, the collection presents an attractive exhibition. The total number of falls or finds represented by genuine specimens is 180, and their total weight is 4,720.6 pounds.

The handbook consists of a concise statement of the facts known concerning meteorites, historical, chemical, physical and cosmical, illustrated by references to the collection itself, with some references to chief authorities and a list of some of the leading works on meteorites.

In reading the sketch, which is interesting and accurate and creditable to its author, two queries rise in the mind of the reader, viz.:

1. Why not mention among the theories that have been proposed for the origin of the chondritic structure of the stony meteorites the view adopted by Proctor and others that the chondri are due to aggregations of cosmic matter? It may not be correct, but as it has played quite a rôle in the literature of the subject it deserves mention when one is listing the various theories proposed for the origin of this structure.

2. Is not the idea that meteorites "explode," producing the detonations which accompany their fall, traditional and imaginary rather than actual? Is not the noise due to the atmospheric agitation produced by the impact? Is there anything naturally or possibly "explosive" in the interior of a meteorite? Is not the fact that the interior of the mass is usually cold sufficient demonstration that the exterior only has been heated and hence, also, that it has suffered the greater amount of expansion? In the firing of a cannon is it the "explosion" proper that is heard, or is it the atmospheric undulation which is produced by the rush of the column of liberated gas into the still air? Would it be possible for a loosely cemented stone, like most meteorites, to fall upon the atmosphere, at the speed with which meteorites travel, without disintegration? Would it not necessarily crumble into many pieces, in the same manner and for the same reason that a pailful of water, suddenly

liberated at a hight, is divided into many parts and perhaps into spray before it reaches the earth? Cannot the different "explosions" of meteorites be all attributed to the passage of so many large masses through the air, or to the atmospheric agitation of their impact on the lower air? Would it be possible to produce the detonations heard at the time of fall by the separation of the meteoric mass into its parts, and at the same time not reduce it to powder? Would not the sudden arrest of a mass of matter like a meteorite produce a noise similar to that heard by the sudden action of the force which starts a cannon ball? Would not the resistance of the atmosphere be such as to cause a comparatively sudden arrest of the motion of a meteorite? N. H. W.

Das obere Mitteldevon (Schichten mit Stringocephalus Burtini und Maeneceras terebratum) im Rheinischen Gebirge. By E. HOLZAPFEL. (Abhandl. der Königl. Preuss. Geolog. Landesanst., Heft 16, pp. 1-460, pls. 1-19, 1895.) The author, widely known for his previous publications upon the Paleozoic faunas of Germany and Bohemia, has here produced the most elaborate and important work of the year upon the Devonian. In a brief sketch it is not possible to do it justice, for it marshals a great array of facts, many of which, though based upon local manifestations, are keyed up to a general significance. The detailed description of the fauna, with which the work opens, evinces this fact in many places throughout the account of its 238 species, and is full of suggestions to the working paleontologist.

The radical differences in the composition of this fauna and that occupying the same stratigraphical position in America are more strongly emphasized than ever. These are not differences which lead in any way to doubt the present assignment of either, but rather to the conviction that the term is yet to be coined which expresses their individual character or mutual relations. Thus, among the multitude of forms in the middle Devonian of America (Marcellus and Hamilton divisions) are species at certain horizons which, in Germany, appear at wholly different planes: *Agoniatites expansus* Vanux. (*A. inconstans* Phillips, var. *expansus*, according to Holzapfel) is preëminently a lower middle Devonian species in New York, but abounds at a higher horizon there. We might cite the limitation of *Tropidoleptus* to the German lower Devonian, while in New York it appears first in the Hamilton group and disappears with the Ithaca fauna. *Schizophoria striatula* and *Leptæna rhomboidalis* are brachiopods generally diffused through the German middle Devonian, but are wanting at the same horizon here. Again, a multitude of types of more than specific value there characteristic are here unknown. A glance at the list of trilobites described by the author enforces this fact. There are *Crotalocephalus*, *Lichas*, *Arethusina*, *Harpes*, forms of *Proetus* (*P. crassirhachis*, *P. quadratus*) which occur only in our lower Devonian, the *Gerastos*-type alone representing this genus in the middle division. Likewise among the cephalopods *Prolecanites clavilobus* represents a goniatite-type unknown here before the opening of the upper Devonian: the nautiloid genera *Cophinoceras* and

Sphyradoceras characterize the American lower Devonian;* the new *Cyrtoceras*-like genus *Kokenia* is unrepresented. Among the gasteropods is one described as typifying a new genus, *Progalerus* (*P. convidens*) which is, however, synonymous with *Protocalyptræa* Clarke, and is known in American faunas only in the upper Devonian. Of the brachiopods, *Amphigenia* is lower Devonian in America: among the crinoids *Cupressocrinus* is here unknown, *Hexacrinus* and *Melocrinus* are virtually restricted to upper Devonian faunas. There are also some notable differences in the intensity of development of certain generic types, as in *Agoniatites* (*Aphyllites*) of which we recognize two or three species in the New York Devonian (*Goniatites expansus* Van., and var *nodiger* Hall, and *G. unilobatus* Hall) and two of these are incorporated by the author among the seven varieties of *G. inconstans* Phill. *Anarcestes* is represented by six species, only one being known here (*A. lateseptatus* Beyr. *Gon. plebeiformis* Hall). *Tornoceras* has nine species, while the middle Devonian of America has produced but two. *Meneceras*, with four species, is not known here unless it be by the little known shell *Gon. orbicella* Hall. *Loxonema* and *Platyceras* fall far below their American development, *Pollicina* and *Agnesia* are not known, the lamellibranchs *Rutotia* and *Parallelodus*, *Hoplomytilus* and *Posidonia* have not been identified here, while *Cardiola* is represented by seven species and *Conocardium* by six. *Merista* is not a middle Devonian genus in America. And yet with such differences there is striking uniformity in the two faunas in the composition of the goniatite, lamellibranch and brachiopod elements.

The author introduces four new genera, viz.: *Kokenia*, a cyrtoceran-looking genus, with obliquely ribbed sides but with no evidence of sipho or septa: it is compared to *Coleoprion* in structure. *Progalerus*, as already observed, a gastropod genus synonymous with *Protocalyptræa*. *Pollicina* (accredited to Koken), a supposed platyceratid with strong rugose growth-ridges. *Chascothyris*, a large terebratuloid brachiopod having a loop extending for half the length of the shell and slightly reflected in front, whence a long and narrow spine projects backward. Its structure suggests a *Rensselæria* in which the anterior plate formed by the coalescence of the descending branches of the loop has been resorbed without affecting the median rod connected therewith and extending toward the crura. It is an interesting modification of centronellid type and is represented by three species, of which *Ch. barroisi* is the typical form.

The genus *Enantiosphen*, which was recently introduced by Whidborne for the brachiopod *Meganteris vicargi* Dav., is regarded by Holzapfel as a synonym of *Amphigenia* Hall, though we believe it would be well to adopt the author's suggestion by applying this term to those middle Devonian shells having a short form and broadly introverted margins (*E. vicargi*, *A. beyrichi*).

*The author repeatedly refers to the Upper Helderberg fauna as of lower middle Devonian age. This is not in accordance with the accepted classification of the American faunas, nor does it agree with our own view. That fauna naturally embraces some middle Devonian types, but its most prominent elements are distinctly of earlier age.

The paleontologic portion of the work, which constitutes its main part, is followed by chapters mainly pertaining to the local developments of the fauna and their correlation. One of these which is concerned with the facies of the fauna in its entirety brings forward with much force objections to the argument of Walther that the fossil remains of ammonoid cephalopods do not, generally speaking, represent members of the faunas with which they are found, but after having been floated by inclosed gases resulting from decomposition have been carried by wind and tide from their deep water habitat in among the shallow water organisms with whose remains theirs are found. Holzapfel shows that the goniatites of the German Devonian prevail wherever the limestones occur, that their number is greatly diminished in shales and sands, while they occur with extreme rarity in coral and crinoid deposits; further that, in respect to generic and even specified types, these fossils are of general distribution in the middle Devonian of both continents. The evidence from equivalent New York faunas distinctively favors this conclusion. Not all the limestones of the Marcellus and Hamilton divisions produce goniatites, but these fossils are most prolific in certain of these layers and at present appear to be closely restricted to narrow horizons, e. g., the almost exclusive development of *Agoniatites expansus* and *Tornoceras discoideum* in the goniatite limestone of the Marcellus shales, and of *Anarcestes plebeiformis* in a local limestone stratum of the same age. Furthermore, the presence of goniatites in highly bituminous or arenaceous sediments of the middle Devonian can not be construed as an argument against this inference for such species are those which also occur involved in the calcareous sediments of that formation. This same fact is strikingly true of the lower Devonian or Intumescens fauna, a fauna emphatically distinct from those preceding and succeeding; its goniatites abound most freely where there is calcareous stratum, but the same species likewise occur in the sandy shales and flags. Moreover, the entire fauna in all its elements is an harmonious whole, reproduced in world-distant regions. J. M. C.

Mollusca and Crustacea of the Miocene Formations of New Jersey. By ROBERT PARR WHITFIELD. (U. S. Geol. Survey, Monograph XXIV, pp. 195, with 24 plates: Washington, 1894. Price, 90 cents). Eight years ago only fifty Miocene species were known from New Jersey; but in the present work the number is increased to 110, of which 36 are found only in this State. "No living forms have been found in the New Jersey deposits that are not also known to occur in some of the more southern localities, and no very close representatives of living species are seen among those which so far are found in New Jersey only." The fossiliferous Miocene beds occur in three phases, namely, in descending order, a dark brown or chocolate-colored clay, which lies next below the "glass sand;" next, a stony layer of gray marl, filled with shells of Ostrea and other forms: and, below this, the loose sandy gray marl. These divisions, however, do not appear to be distinctly separable zoologically, and they are therefore thought to be due merely

to local changes in conditions during the continuance of the same epoch. The species described in this work, represented mostly by collections belonging to the National Museum, the Academy of Natural Sciences of Philadelphia, and Rutgers College, are comprised in the following classes: Brachiopoda, 1: Lamellibranchiata, 61: Gasteropoda, 39: and Crustacea, 1, this being a Balanus, similar to the common barnacle still living on the New Jersey coast. W. P.

A Geological Reconnoissance in Northwest Wyoming. By GEORGE HOMANS ELDRIDGE. (U. S. Geological Survey, Bulletin 119, pp. 72, with a geologic map and sections: Washington, 1894. Price, 10 cents.) An area about 150 miles square in Wyoming, with an adjoining tract 150 miles long and 15 miles wide in Montana, is here described, special attention being directed to its economic resources. The district comprises the Wind River and Big Horn basins, each nearly inclosed by high mountain ranges, and drained respectively by upper and lower parts of the same river. The rock formations are of Archean, Cambrian, Silurian, Carboniferous, Triassic, Jurassic, Cretaceous, and Eocene age. Archean granites, gneisses, and schists, form the chief mass of the Big Horn and Wind River mountains: but the southern part of the Big Horn range consists of Carboniferous strata. All the members of the Cretaceous series, as developed in the Upper Missouri region, are displayed on the flanks of the numerous mountain ranges. Lastly, in the lowlands, the Wasatch and Bridger deposits of the Eocene period occupy larger areas than those of the older formations in this district.

Lignite coal seams, mostly too thin to be workable, but ranging in thickness up to ten feet, occur in the Laramie formations: and in one locality the Niobrara beds contain a lignitic layer about two feet thick.

Petroleum springs issue in various places from the Triassic red beds and the Niobrara shales. Three oil wells, 400, 600, and 1,000 feet deep, have been sunk, and yield an abundant and steady surface flow, when it is permitted: but they are kept closed because of the distance from any market. "The natural occurrences of oil, and the success thus far attained in the drilled wells, warrant firm and favorable belief in the future of the Wyoming petroleum fields."

Building stones of excellent quality, clays well adapted for brick-making, beds of gypsum 5 to 30 feet thick, gold in certain conglomerates and sandstones on the Big Horn range, several very large hot springs held in high repute for their curative qualities, and the scanty agricultural lands within irrigable limits, complete the list of the natural resources of the region. Away from the mountains and streams, the country is "a vast desert, intensely heated in summer, wind-swept in winter, with hardly a spear of grass for grazing." W. P.

Elementary Physical Geography. By RALPH S. TARR. (Pages xxxi, 188, with 29 plates and charts, and 267 figures in the text. Macmillan & Co., 1895. Price $1.40.) The present treatise, designed as a text book for schools, is based on the manuscript of a more advanced work, which is soon to be published as a handbook for teachers and for reference.

In the first part, treating of the air, the outlines of the fast advancing science of meteorology are presented, with a chapter on the geographic distribution of animals and plants as dependent chiefly on climatic conditions. The second part treats of the ocean, its abyssal deposits, its faunas in varying depths, and its waves, currents, and tides. In the remaining third part, which occupies more than half of the book, the land is considered. All the chapters of this part, relating to the crust of the earth, denudation, topographic features, river valleys, deltas, floodplains, lakes, glaciers, the coast line, plateaus and mountains, volcanoes, earthquakes, and geysers, and the relationship of man and nature, are very instructively and attractively arranged. The whole field is viewed, and its lessons are stated, from the standpoints not merely of the geographer, but likewise of the geologist, with due regard to the common ground of geomorphology, where the earth's present surface features are shown to have come through long antecedent stages of gradual development by geologic conditions and agencies.

The abundant illustration by charts and diagrams, and especially by the admirable "half tone" engraving in its clear copies of photographs with all their fidelity to the truth, well exemplifies the recent great progress in this important auxiliary for imparting school instruction. The pupil finds at the end of each chapter a short list of the most useful books to be sought in libraries for further pursuit of that portion of the subject; but both teachers and students are urged to supplement the study of the text book by field excursions and observation. W. U.

The Lakes of North America: A reading lesson for students of Geography and Geology. By ISRAEL C. RUSSELL. (Pages xi, 125, with 23 plates, and 9 figures in the text. Ginn & Co., 1895.) The six chapters of this interesting and convenient reference book for schools, colleges, and general readers, are (1) origin of lake basins, in which the author follows mainly the classification of Davis; (2) movements of lake waters and the geological functions of lakes; (3) topography of lake shores, nearly as in the classical work on lake Bonneville by Gilbert, to whom this book is dedicated; (4) relation of lakes to climatic conditions; (5) the life histories of lakes; and (6) studies of special lacustral histories, including the Pleistocene lakes of the Laurentian basin, the glacial lake Agassiz in the Winnipeg basin, and the Pleistocene lakes Bonneville and Lahontan in the present Great Basin of interior drainage within the broad Cordilleran mountain belt. Excepting occasional typographic errors, mostly unimportant, the work is excellently done by an author who has contributed much original investigation in this field by his work for the U. S. Geological survey in explorations of lake Lahontan, the formerly higher stages of lake Mono, and many other smaller Pleistocene lakes due to a more moist climate in the Cordilleran region than that of the present time. W. U.

Characteristics of the Ozark Mountains. By C. R. KEYES. (Missouri Geol. Survey, vol. VIII, pp. 319-352. Jefferson City, 1895.) This paper is in the main a summary of what is known regarding the Ozark

mountains. Under the term Ozark uplift the author would include the Shawnee hills, St. Francois mountains, Ozark plateau, Boston mountains and Ouachita mountains. The uplift as a whole is a canoe-shaped dome extending from southern Illinois to Indian Territory. It stands as a dividing line between the coastal plain, as represented in the Mississippi embayment, and the Great plains. The middle of the uplift is a typical high plateau: around the margins are the areas of more pronounced topographic diversity known by the different local names given above. Each is considered separately. The Shawnee hills are ridges and represent structural features. The St. Francois mountains are made up of isolated peaks irregularly clustered. The Boston mountains form a range of steep-sided elevations lying between the White and Arkansas rivers. The Ouachita mountains show numerous anticlinal ridges. They are believed to belong structurally with the remainder of the group, the separation being due to the more rapid erosion of the Coal Measure shales.

The crystalline rocks of the region belong to two distinct periods, the granites and porphyries to the Archean and the eleolite syenites to the Cretaceous. The recognition of the Algonkian is considered as provisional only. The Ozark series is believed to include both Cambrian and Silurian, separated possibly by an unconformity, that seen at Pacific. The presence of numerous unconformities, as indicative of repeated oscillations, and the freshness of the stream erosion, as evidenced in the sharpness of the valleys and the dissection of the Tertiary peneplain, are insisted upon as evidence of the recentness of the uplift. It is believed, indeed, that the last cycle of elevation is not ended and that elevation is now taking place at a rapid rate. H. F. B.

RECENT PUBLICATIONS.

I. Government and State Reports.

Geol. Survey of Canada. Maps of the principal auriferous creeks in the Cariboo mining district, British Columbia, by Amos Bowman; maps 364-372.

Geol. Survey of Canada. Maps of Nova Scotia, described in part P, vol. 2 (n. s.), 1886; maps 379-390, 550, 551 (sheets 25-38).

Geol. Survey of Canada. Seine River sheet of Thunder Bay and Rainy River districts: geology by W. H. Smith and W. McInnes.

Missouri Geol. Survey, vol. 8, Ann. Rept. for 1894, 405 pp., 30 pls., 1895. Organization and results of a state geological survey, C. R. Keyes; Crystalline rocks of Missouri, Erasmus Haworth; Dictionary of altitudes, C. F. Marbut; Characteristics of the Ozark mountains, C. R. Keyes; Coal Measures of Missouri, G. C. Broadhead.

11th Ann. Rept. of the Inspector of Mines of Ky., for 1894, viii and 207 pp., 1895. Report of the Inspector, C. J. Norwood; Correlation of Kentucky coals with those of Big Stone Gap, Va., J. M. Hodge.

U. S. Geol. Survey. Lassen Peak folio (Cal.) of Geologic Atlas U. S., J. S. Diller.

II. Proceedings of Scientific Societies.

Proc. Acad. Nat. Sci. Phila., 1895, pt. 2. Distribution of the American bison in Pennsylvania, with remarks on a new fossil species, S. N. Rhoads: Protoptychus hatcheri, a new rodent from the Uinta Eocene, W. B. Scott.

Trans. N. Y. Acad. Sci., 1894-'95, vol. 14. Dislocations in certain portions of the Atlantic Coastal Plain strata and their probable causes, Arthur Hollick: The geological section exhibited by the new tunnel under the East river at 70th street, J. F. Kemp: Phosphorescent diamonds, G. F. Kunz: The Protolenus fauna, G. F. Matthew: Two new Cambrian graptolites, with notes on other species of Graptolitidæ of that age, G. F. Matthew: The effusive and dyke rocks near St. John, N. B., W. D. Matthew: On a granite diorite near Harrison, Westchester county, N. Y., H. Ries: The condition of the interior of the earth (abstract), R. S. Woodward.

Proc. and Trans. Nova Scotian Inst. Sci., vol. 8 (2d ser., vol. 1), pt 4, 1895. Notes on a collection of Silurian fossils from cape George, Antigonish Co., N. S., with descriptions of four new species, H. M. Ami: Notes on recent sedimentary formations on the Bay of Funday coast, R. W. Ells: Deep mining in Nova Scotia, W. H. Prest: Notes on the Sydney coal field, E. Gilpin.

III. Papers in Scientific Journals.

Amer. Naturalist, Nov. The first fauna of the earth, J. F. James.

Amer. Jour. Sci., Nov. Effect of the mutual replacement of manganese and iron on the optical properties of lithiophilite and triphylite, S. L. Penfield and J. H. Pratt: Some phonolitic rocks from Montana, L. V. Pirsson: Reptilia of the Baptanodon beds, O. C. Marsh: Restoration of some European dinosaurs, with suggestions as to their place among the Reptilia, O. C. Marsh.

Science, Oct. 25. View of the Ice age as two epochs, the Glacial and Champlain, Warren Upham.

Science, Nov. 8. Current notes on physiography (XVII), W. M. Davis: Radiolarian earths of Cuba, R. T. Hill.

Science, Nov. 15. Current notes on physiography (XVIII), W. M. Davis.

Journ. of Geol., Oct.-Nov. The cliffs and exotic blocks of north Switzerland, E. C. Quereau: Preglacial valleys of the Mississippi and its tributaries, Frank Leverett: The upper Palæozoic rocks of central Kansas (concluded), C. S. Prosser: The volcanics of the Michigamme district of Michigan, J. M. Clements: The influence of débris on the flow of glaciers, I. C. Russell: Glacial studies in Greenland (VIII), T. C. Chamberlin.

IV. Excerpts and Individual Publications.

Elementary physical geography, R. S. Tarr. 12mo, xxxi and 488 pp., 29 pls.: New York, Macmillan & Co., 1895.

Petrology for students, an introduction to the study of rocks under the microscope, Alfred Harker. 12mo, viii and 306 pp.: New York, Macmillan & Co., 1895.

The lead and zinc mining industry of southwest Missouri and southeast Kansas. John R. Holibaugh. 8vo, 54 pp., and map: New York, The Scientific Publishing Co., 1895.

Description of eight new species of fossils from the (Galena) Trenton limestones of lake Winnipeg and the Red River valley, J. F. Whiteaves. 11 pp.: reprint from Canadian Rec. Sci., July, 1895.

Die krystallisirten Mineralien aus dem "Galena Limestone" des südlichen Wisconsin und des nördlichen Illinois, W. H. Hobbs. Zeitschrift f. Krystallogr., xxv, 257-275, Taf. 3-5, 1895.

Mount Shasta, a typical volcana, J. S. Diller. Nat. Geographic Monographs, vol. 1, no. 8, pp. 237-268, Oct., 1895.

The dyke on the Columbia vein in Ward district, Boulder Co., Colo., C. S. Palmer and W. B. Stoddard. 6 pp.: read before Colo. Sci. Soc., Oct. 7, 1895.

V. *Proceedings of Scientific Laboratories, etc.*

Johns Hopkins Univ. Circulars, Oct. Description of the geological excursions made during the spring of 1895, W. B. Clark: Two new brachiopods from the Cretaceous of New Jersey, W. B. Clark: Contributions to the Eocene fauna of the middle Atlantic slope, W. B. Clark: Additional observations upon the Miocene (Chesapeake) deposits of New Jersey, W. B. Clark: Notes on some flattened garnets from North Carolina, E. B. Mathews: A contribution to the Neocene corals of the United States, H. S. Gane: The spotted slates associated with the Sioux quartzite, S. W. Beyer: The Cretaceous Foraminifera of New Jersey, R. M. Bagg: The volcanic series of Fox islands, Maine, G. O. Smith: A preliminary note on the geology of Massanutten mountain in Virginia, A. C. Spencer: Preliminary description of the geology of the Bordentown sheet of the geologic atlas of the United States, G. B. Shattuck: The discovery of fossil tracks in the Newark system (Jura-Trias) of Frederick county, Md., J. A. Mitchell: Note on the Cretaceous formations of the eastern shore of Maryland, D. E. Roberts: Notes on the paleontology of the Potomac formation, Arthur Bibbins.

CORRESPONDENCE.

Dr. Holst on the Continuity of the Glacial Period. The Geological Survey of Sweden has just published an important paper (No. 151) by Dr. N. O. Holst, entitled "Har det funnits mera än en Istid i Sverige?" ["Has there been more than one Ice Age in Sweden?"], in which Dr. Holst intimates that fashion has had much to do with introducing and supporting the theory of two ice ages in Scandinavia. After detailing the subdivisions of the glacial advance and retreat which by some geologists are confidently attributed to distinctly separate glacial epochs, he maintains that the facts have been greatly misinterpreted and that he finds no sufficient evidence of successive and distinct ice-sheets or epochs of glaciation.

Much weight attaches to what Dr. Holst writes about American facts, inasmuch as he traveled extensively in this country in 1891, and was conducted to the critical points of glacial investigation by Prof. Salis-

bury and others; and the value of his conclusions is further increased by the extended observations made by him several years before on the glaciers of southern Greenland. "The general moraine," he says, "which can be compared with that in Scandinavia, ends in North America in a bouldery belt inclosing small lakes, with drift hills and ridges sometimes 150 to 300 feet high, trending commonly in a direction at right angles to the glacial striæ. This moraine belt is somewhat like the Swedish hilly moraine landscape. It is this ridged belt that is called the terminal moraine. Americans consider themselves able to trace this from east of New York along the south side of the Great Lakes into Dakota to the east bank of the Missouri, also farther along that river toward the north and northwest.

"These terminal moraines, according to the interglacial conceptions, are supposed to mark the southern boundary of the American ice-sheet during the second glacial epoch or ice age. But south of this belt is found a considerable tract which adjoins it as a border, and which is characterized in general by less severe glaciation, and, on the whole, by a thinner and less complete covering of glacial deposits. This tract has been called 'the fringe,' or, to use a term of the interglacialists, the 'attenuated border.' The larger part of this is attributed to the first ice age.

"When Chamberlin in 1883 expressed himself more certainly for the interglacial theory he founded his convictions on two reasons, the first of which was the position of the 'terminal moraine.' Since then, however, it has been discovered that there are several such morainic belts which lie concentric one inside the other. If one lets the most southern moraine prove a separate ice age, it becomes hard to understand why the same importance should not be given to the other remaining moraine lines.

"In 1886, Chamberlin and Salisbury gave a more complete sketch of the differences between the two ice epochs. The first was less powerful, scattered its material more uniformly, and did not generally pile it up in moraine ridges; wherefore terminal moraines and drumlins are wanting. Further, the glacial erosion was weaker, so that the water systems of the drift area south of the moraines have few lakes or rapids.

"During the last ice age the conditions were nearly the reverse. The glaciation was quite strong, and immense terminal moraines were plowed up. The mountain sides were strongly eroded, and the streams flowed with great power in their courses, sending vast masses of glacial gravels from the edge of the ice far down into the valleys, which they filled to a great depth with well assorted material.

"But this so-called proof, the writer dares maintain, speaks directly against the theory of the interglacialists. If North America had two ice ages, of which the first, after having covered nearly one-half of the continent, melted so completely that it left the country in an interglacial condition free from ice as now, it certainly is very peculiar that the ice of the succeeding epoch should reach almost as far as that of the first. It is even more peculiar that the action of the first and maximum ice

sheet should have been weaker than that of the second: and it is most remarkable of all that the first continental glacier should have failed to deposit moraine ridges and other sediments which usually belong to land ice. The case, however, becomes both simple and natural if each of the above groups of facts be regarded as more or less marginal, belonging in one and the same ice epoch. The smaller amount of erosion and weaker glaciation outside of the terminal moraines need with this conception no separate explanation.

"Other proofs, considered even more important, are derived from the extensive oxidation and erosion which the oldest glacial drift has undergone, and which are supposed to have required a very long interglacial epoch: and finally, the vegetation and interglacial forest layers imbedded in the drift bounded by the moraines are thought to be specially significant.

"But the oxidation of the oldest drift (the fringe) is characteristic of the eastern as well as of the western border of the glaciated area. It is very thorough, showing a strong yellow-brown or reddish color, and in some instances it extends to a depth of twenty or thirty feet, and is as thorough at the bottom as near the top. This is the case in the region of Oxford Furnace, N. J., where the writer, under the guidance of Salisbury, had a chance to get acquainted with it in 1891. But in this locality, considered especially important, the oxidation appeared to be entirely too deep, too uniform downward, and altogether too thorough, to have taken place during the Quaternary era. Clearly the material of which the sediments in question are formed must have been already strongly oxidized before it was deposited. The oxidation was thus preglacial." [Reference is here made in a footnote to my reports upon the region as in harmony with the author's.] "The writer has come to this conclusion in view of the experience which he has had in Sweden in observing the Quaternary oxidation and weathering, which decrease generally downward....

"Salisbury has besides, together with Chamberlin, published facts derived from their American investigations which give a more correct estimation of the extent of the Quaternary oxidation. They state that the loess is often oxidized to a depth of four to five feet, and also in some places deeper. But it is very hard to understand why the interglacial oxidation should have affected the Mississippi loess and the older New Jersey glacial deposits in such very unlike manner, although they were formed at the same time, or at least during some part of the first ice age."

After discussing the nature and supposed extent of the interglacial erosion, and outlining the theories of Chamberlin and Salisbury concerning the loess, Dr. Holst speaks of the light thrown upon this deposit by the "kryokonite," or dust found on the Greenland ice-sheet, which, he says, shows a complete resemblance to the loess, and, "if the writer is not mistaken, is the origin of a similar mud-making process with that which has produced the loess. The water which circulates upon and beneath the outer portions of the ice washes the finer material which is

scattered over the margin of the inland ice, and which is inclosed in the layers of the decaying ice front, out against the moraine, but leaves in the ice the other material which is not fine enough to pass away as clay mud. In this way the loess, as well as the clearly similar mud products of Greenland, receive an entirely satisfactory explanation."

After remarking upon the diminished importance of interglacial forest beds since Prof. Russell's discoveries in Alaska, and upon their occurrence chiefly in the marginal area, Dr. Holst says that "if in reality the glacier which once covered almost half of North America could have entirely melted away, permitting an interglacial epoch many times longer than the postglacial, when the country was free from ice as now, vegetation and soil ought, at least to as large an extent as now, to have taken possession of the surface; and when an ice-sheet a second time moved forward to the former boundary line, it ought to have buried, and in numerous cases to have eroded, but not to have wholly removed, the interglacial layers. We should, therefore, now find in innumerable places under the later moraines vegetation and interglacial soil; and, further, we ought to find in the morainic drift, fragments of bones, shells, wood, and other organic remains almost without number, and finally in some places one ought to come upon outside layers of interglacial age. But, except in the marginal part of the drift area, one finds nothing of all this."

Dr. Holst further remarks upon the difficulty encountered in the attempts to correlate the glacial and interglacial epochs of Europe and America. "The same yellow and blue moraines which in Scandinavia and northern Germany are supposed to represent two ice ages are also found in North America. I have seen them myself in Ohio, but there they are wholly attributed to the later ice age....The loess, which in Europe belongs to the second ice age, in America is supposed to belong to the first," etc.

In conclusion the distinguished Swedish author expresses it as his opinion that there can not be the strong cumulative force in the arguments brought forward by the multi glacialists which has been attributed to them, since each argument, when weighed separately, is insufficient. He affirms that, during his wide travels in the investigation of the facts in question, he finds nowhere any decisive proof of the hypothesis of an interglacial epoch. Nowhere in foreign countries is any fact met that can be considered to make it unlikely that in Sweden there was only one ice age.

G. FREDERICK WRIGHT.

Oberlin, Ohio, Nov. 15th, 1895.

PERSONAL AND SCIENTIFIC NEWS.

DR. R. M. BAGG has been appointed assistant in geology in the Johns Hopkins University.

ANTONIO DEL CASTILLO, F. G. S. A., director of the Mexican Geological Commission, died in the city of Mexico on October 27th.

PROF. CLEVELAND ABBE, of the United States Weather Bureau, will give four lectures upon "Climatology in its relation to physiography" before the geological department of Johns Hopkins University on Jan. 6th, 7th, 8th and 9th, 1896.

CHARLES SCRIBNER'S SONS announce the publication of "The Earth's History, an introduction to modern geology," by R. D. Roberts, lecturer in the University of Cambridge; and "The Realm of Nature," by Hugh R. Mill, of the University of Edinburgh.

THE NATIONAL ACADEMY of Sciences met in Philadelphia on Oct. 29th and 30th. The following geological papers were presented: On the Paleozoic reptilian order of the Cotylosauria, by E. D. COPE: On a bone cave at Port Kennedy, Pa., by E. D. COPE; On borings through the coral reef in Florida, by ALEXANDER AGASSIZ.

THE EIGHTH WINTER MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA will be held in Philadelphia, probably at the University of Pennsylvania, beginning Thursday, Dec. 26th. The council meets Thursday morning and the society will be called to order at two o'clock on Thursday afternoon. The list of papers will be distributed on Dec. 11th.

THE JOHNS HOPKINS UNIVERSITY announces that SIR ARCHIBALD GEIKIE, F. R. S., D. Sc., LL. D., Director-General of the Geological Survey of Great Britain and Ireland, has accepted the invitation of the president and board of trustees of the Johns Hopkins University to inaugurate the George Huntington Williams memorial lectureship, and has selected October, 1896, as the time for delivering his lectures.

THE GEOLOGICAL SOCIETY OF WASHINGTON held its 37th meeting on Nov. 13th. The following papers were presented: A review of the literature of the South African gold fields, by S. F. EMMONS: Informal summary of observations in Alaska, by G. F. BECKER and W. H. DALL. At the meeting on Nov. 27th the following papers were presented: Field notes on the geology of Oregon, by J. S. DILLER: Geology of the Sonora sheet, Cal., H. W. TURNER: Notes on magnetic ore, Snoqualime, Wash., BAILEY WILLIS and G. O. SMITH: Remarks on the Black hills, N. H. DARTON.

GEOLOGICAL SURVEY OF CAPE COLONY. It is announced that a commission has been appointed to undertake a systematic geological survey of this district. One of the first efforts of the commission will be to prepare a bibliography of publications relating to the geology of the region.

DURING THE PAST SUMMER DR. LEONHARD STEJNEGER, while at Bering island, was fortunate enough to secure some bones of Pallas' cormorant at the locality where he had found others in 1882. At the time these were the only known bones of this extinct species. Among the more recently obtained specimens is a fairly complete cranium which is somewhat larger than that of any existing species, and is peculiar in the character of the ethmoid and opening in the front of the cranium. Mr. Grebnitski has also procured some remains of Pallas' cormorant from the same deposit. (*Science.*)

"GREENLAND ICEFIELDS," a new volume of the International Scientific Series, by Prof. G. FREDERICK WRIGHT and Mr. WARREN UPHAM, is announced among the publications of Appleton & Co. for the present month. Prof. Wright, in seven chapters, describes the floe ice of the Labrador and Spitzbergen currents, his observations on the coasts of Labrador and Greenland in the Miranda expedition of last year, the Eskimos, and the Danish settlements. In the next seven chapters Mr. Upham writes of the flora and fauna of Greenland, the explorations of the Greenland ice-sheet by Nordenskjöld, Nansen, Peary and others, the Pleistocene glaciation of North America and Europe, and the causes of the Ice age. The book will be illustrated by several maps and many figures from photographs.

THE GEOLOGICAL SURVEY OF CANADA has issued, in advance of the report, a geological map (Seine River sheet of the Thunder Bay and Rainy River districts) of the Seine River district of southwestern Ontario. This comprises the region directly east of the Rainy Lake gold fields. The belt of Keewatin green schists, in which occur many of the gold veins of Rainy lake, extends eastward through this Seine River district, and already many mining locations have been taken within the limits of this map. There are also deposits of iron ore known in the Keewatin rocks in the center of this district along the Atikokan river. The whole region covered by this map is underlain by rocks of pre-Cambrian age, a large part of which are gneisses and granites. The geological work was done by Messrs. W. H. Smith and Wm. McInnes, and the map is to illustrate the report of Mr. McInnes in volume 7, 1895, of the Annual Report of the Geological Survey of Canada.

THE WISCONSIN ACADEMY OF SCIENCES, ARTS, AND LETTERS will hold its annual meeting at Madison on Thursday, Friday, and Saturday, Dec. 26th, 27th, and 28th. The sessions will

be in the rooms of the Academy in the Capitol building. On Thursday there will be afternoon and evening sessions, and on Friday there will be morning and afternoon sessions. The annual supper of the Academy, provided by the local members, will be given Friday evening. According to the usual custom, after supper there will be an informal discussion upon matters concerning the welfare of the Academy. At this time will come up the question as to whether another attempt shall be made to secure the passage of the bill, drawn by the Academy, for the establishment of a geological and natural history survey, and if it is decided to press the measure, the methods to be adopted will be considered. If the program is not completed Friday afternoon, the final session will occur Saturday morning. The Wisconsin Academy is the official society of the State, occupying the same relation to Wisconsin that the National Academy does to the United States. Liberal provision is made by the State for the publication in excellent form of suitable papers. Special invitations for papers have not been made. The privilege of reading papers is equally open to all members. Titles of papers and time required for presentation should be sent to the president or secretary on or before Dec. 1st., so that these may be printed in the final announcement of the meeting.

FIELD WORK OF THE U. S. GEOLOGICAL SURVEY. In *Science* for Nov. 8th appears the following note concerning the field work of the U. S. Geological Survey:

Director Walcott, of the U. S. Geological Survey, has returned to Washington after a two months' absence in the northern Rocky Mountain region, spent in field work. He was studying the Cambrian rocks and faunas of Montana and Idaho.

The field work of the season is drawing to a close. Nearly all the geologic parties have come in, though work is still going on on the Pacific coast, and, to a small extent, in the Interior or Mississippi basin. Work in the northern Rocky Mountain region and in Washington was brought to a stop early in October by severe storms. In this region Mr. Emmons and Mr. Willis were at work as well as the director. The special work in Alaska, an examination of the gold and coal resources, was advanced so far as conditions would permit, and Drs. Becker and Dall are now in Washington preparing their joint report on the subject. Since submitting to the Secretary of the Interior his report on the character of the lands involved in the McBride claim in Washington, Mr. W. Lindgren, who made the expert examination for the Government in that case, has been mapping the geology of the mining region of northern central California.

Topographic work is still in progress in all quarters. The number of sheets surveyed is unusually large and the work is generally of excellent character. Surveys are, or have been, in progress in about twenty-five states and territories. The Chief Topographer, Mr. Henry Gannett, made an inspection of the work, especially that in the west. The work going on in Indian Territory is of special interest because of the peculiar conditions governing it. Here, in connection with the regular topographic mapping, a sub-divisional or parceling survey is being made in the interest of the General Land office. This work was much retarded

in the summer months, partly by the illness of the men, due to the prevalence of malarial fever, and partly to other unforseen obstacles; but the conditions have improved and the work is now advancing with gratifying rapidity. This work will go on all winter.

Director Walcott will shortly prepare a succint report of the operations of the field season, for the information of the Secretary of the Interior, briefly reviewing the work in all its branches.

Geological Survey of New York.

There have recently appeared in the daily papers of New York city, in the *Engineering and Mining Journal* and in *Science*, articles purporting to give an account of the current work of the geological survey of the state of New York. These have probably had their origin in the unintelligent work of the space reporter, and they seem to have been largely derived from one another. All are inaccurate, a fault more pardonable in a daily newspaper than in the two scientific journals mentioned. The doings described are those of the recently organized land survey which is equipped solely for topographical work.

The geological survey, by the more than usual consideration of the last legislature, has had a very busy and profitable season in the field, a number of special assistants having been active in various parts of the state. Professors J. F. Kemp and H. P. Cushing have been continuing their study of the crystallines in Essex, Clinton and Hamilton counties. Prof. C. H. Smyth, Jr., is engaged with the structural and economic geology of the western crystallines in St. Lawrence, Jefferson and Lewis counties. Professors C. S. Prosser and J. M. Clarke have been studying the problems presented by variation and distribution of the Portage, Ithaca and Oneonta formations, the former in Otsego, Delaware, Schoharie and Albany counties, and the latter in Chenango, Cortland and Schuyler counties. Mr. D. D. Luther has also given some time to the tracing of the more westerly extension of the Portage-Chemung contact line. Dr. Heinrich Ries has made a stratigraphic and economic survey of Orange county, Dr. D. F. Lincoln one of Seneca county and Mr. I. P. Bishop one of Erie county.

The work has been accomplished with the help of a legislative appropriation for the prosecution of the geological map of the state, of which a proof edition of a preliminary issue is to be at once published by the U. S. Geological Survey, by virtue of an arrangement made ten years ago between the state geologist and major Powell and continued in force by the present director. The preliminary edition will be small, but sufficient to supply the colleges, high schools and academies of the state. With the aid of the legislature work will be continued upon the still unsolved problems presented by certain regions of the state for incorporation upon a future edition of a more complete map.

Under a special provision for the continuation of investigations pertaining to the geology and production of salt, Mr. D. D. Luther is employed in the collection of data, much of his time thus far being given to the study of the developments in Onondaga county, and the economic geology of that county will be published as a special part of his report.

In the matter of publication the year has been a fruitful one. Toward the end of 1894 appeared part 2 of volume VIII of the "Palæontology of New York" with which the work known for so many years under that title and as part of the "Natural History of New York" is formally closed. The termination of this work is not due to any intention on the part of the venerable head of the survey to discontinue investigations in paleontology, but is the outcome of embarrassing complications which have arisen in late years over the superintendence of the publication. Evidence of the annoyance which has come from this source is the fact that of this large volume completing the study of the genera of the Brachiopoda, upon which work had been carried forward consecutively for seven years, but one hundred copies have been printed and these were completed at the personal cost of Prof. Hall, after an appropriation for the publication of the entire edition had been lost through unfavorable influences, notwithstanding the good will of the legislature in providing the necessary amount.

The annual report for 1893, consisting of two royal octavo volumes of 1,000 pages and numerous plates, was issued early in the year. This report embraced, in addition to much geological matter, the final part of the "Handbook of the Brachiopoda" which was begun in the report for 1891.

The legislature of 1895 provided for the publication of a monograph of the fossil reticulate sponges. The preparation of this work is essentially completed and the printing will soon commence. The book will be of elegant proportions, contain sixty lithographic plates and constitute number 1 of the "Memoirs" of the geological survey.

Much publicity has been given to a bitter personal attack upon the state geologist made in the summer by the secretary of the board of regents of the State University before a committee of the legislature. This was one of the galling experiences of which every one engaged in official scientific work may expect a share, and which are bound to embarrass and delay the progress of science. The extreme invidiousness of the attack aroused a wide-spread sympathy and interest in professor Hall and his work, and under the probing of the committee its baselessness was exposed and the incident has resulted in justifying the official conduct of the state geologist and in strengthening his department.

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Errata for Volume XV.

P. 286, line 7 from the top, for "distributed" read disturbed.
P. 301, line 12 from the top, for "Adirondack" read Taconic.

Errata for Volume XVI.

P. 18, last line in foot note, for "XIV" read XV.
P. 120, line 12 from the bottom, for "ever" read even.
P. 240, line 3 from the top, for "applicable" read capable.
P. 242, between lines 5 and 6 from the bottom, a line has been omitted; supply, Keweenawan and the reddish sand-stones of the.
P. 24[illegible], line 21 from the bottom, for "*Uniformity*" read *Physiography*.
P. 254, line 10 from the top, for "section" read sections.
P. 256, line 24 from the top, for "*Plateaux quilt mat*" read *Plateaux quilt lmx*.
P. 261, line 10 from the bottom, for "*specta bilis* LX" read *F. spectabilis* Lx.
P. 278, at end of last line insert, never.
P. 287, line 11 from the bottom, for "seventh" read twelfth.

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